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Production

The U.S. Primary Iron and Steel Industry Since 1958

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Studies in the Economics of Production:

THE U.S. PRIMARY IRON AND STEEL INDUSTRY SINCE 1958

U.S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

Sidney L. Jones
Under Secretary for Economic Affairs

John E. Cremeans
Director, Office of Business Analysis

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PREFACE

The Economics of Production in the U.S. Primary Iron and Steel Industry Since 1958 is a product of the Industrial Analysis and Productivity Research Program (IAPR) of the Office of Business Analysis. Instituted and directed by Michael F. Mohr, Director of the Division of Capital, Energy, and Productivity Studies, the program's purpose is to assist economic policymakers by providing a systematic body of microeconomic information on the factors that have affected the production process of individual U.S. industries and that have determined their current state of economic vitality. 1/

This is the third of a series of **Economics of Production** reports designed to provide a comprehensive collection of analyses of selected U.S. industries. 2/ These reports are intended for government and business policymakers. Although data availability restricts much of the analysis contained in this report to the 1958-80 period, where possible the analysis has been extended to more recent years.

PART I defines the U.S. primary iron and steel industry (SIC 331) and examines recent developments that are particularly important to assessing its current state and outlook. It also develops and analyzes broad, long-run trends in production, consumption, technology, and import penetration that have contributed to the historical profile of the industry since 1958.

PART II analyzes the evolutionary changes that have occurred in the quantity, quality and price dimensions of the major input categories -- capital, labor, energy, and materials -- used in the production process of the primary iron and steel industry. PART II concludes with a description of the input substitution patterns that have occurred since 1958 and relates these patterns both to the development and use of new technologies and to the relative growth in the prices paid for the services of individual inputs.

PART III synthesizes and summarizes the major findings from PART II within the context of a comprehensive analysis of the industry's performance as an efficient producer. Important changes and trends discussed in PART II are translated into a framework which emphasizes the linkage between the industry's ability to compete and the growth patterns of its input prices, productivity, and unit costs of production. Using this framework, PART III analyzes the U.S. primary iron and steel industry's performance with respect to:

- the relationship between its unit output prices and unit total costs;
- the relationship between its market power and its rate of price markup over costs, return to capital and employee compensation rates;
- the productivity growth obtained from its inputs -- both total factor and single factor productivity -- relative to that achieved in other selected U.S. manufacturing industries;
- the relationship of its input-specific unit costs of production to input-specific productivity and price experiences;

1/ A full discussion of the IAPR program is found in "An Introduction To The Industrial Analysis and Productivity Research Program of The Bureau of Industrial Economics", BIE Staff Paper No. BIE-SP80-1, November, 1980.

2/ Two other reports in the **Studies In The Economics of Production** series are available: "The U.S. Plastics and Synthetic Materials Industry," May, 1985; and "The U.S. Motor Vehicles and Equipment Industry," June, 1985.

- the evolving contribution made to the growth in its non-capital unit total cost of production by each of three broadly-defined noncapital inputs to its production process; and
- the performance of the primary iron and steel industry in controlling its total input and individual input production costs, compared with the performances of other selected U.S. manufacturing industries.

This report was prepared under the general supervision of John E. Cremeans, Director of the Office of Business Analysis. It was jointly produced by the Business Issues Analysis Division, the Statistical Staff, and the Capital, Energy and Productivity Studies Division. Kan Young and Ann Lawson of BIAD, and Paul Christy, Robert Wendling and Michael F. Mohr of CEPS contributed to Part I; Ken Rogers and Lorraine Pitts of the Statistical Staff, and Paul Christy, Joseph Correia, Joseph Modrak, Michael F. Mohr, Betty Ng, and Robert Wendling of CEPS developed all the tables and graphs used in this report and wrote PARTS II and III. Flora Cole and Saundria Pitts, assisted by Jean Shamberger, provided the word processing support.

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EXECUTIVE SUMMARY

"The U.S. Primary Iron and Steel Industry Since 1958", a report in the **Studies In The Economics Of Production** series, is based on new estimates of output, investment (including pollution abatement investment), capital stocks, capacity utilization, return on investment, composition of the labor force, labor compensation, and energy and material inputs.

These estimates were prepared by the Office of Business Analysis (OBA) based on data from the Census Bureau, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and other government and non-government sources. Additional post-1980 data are used when available, but the core data base for the study covers the 1958-1980 period. This report utilizes these data to present analyses of the steel industry which were not previously possible.

DEFINITION OF THE INDUSTRY

The U.S. primary iron and steel industry is defined in this report as Standard Industrial Classification (SIC) code 331; it consists of the following sub-industries, listed by share of 1982 steel industry shipments: SIC 3312, Blast furnaces and steel mills, 78%; SIC 3317, Steel pipes and tubes, 8%; SIC 3316, Cold finishing of steel shapes, 7%; SIC 3315, Steel wire and related products, 5%; and SIC 3313, Electrometallurgical products, 2%.

The last two decades have seen the evolution of two separate, though interdependent, types of producers in the steel industry: (1) the traditional **integrated companies** that rely primarily on the open hearth and basic oxygen technologies to convert iron ore to iron and steel and ultimately to the mill products that are the basic output of the industry and (2) the **"mini-mill" companies** that use electric-arc furnaces and scrap or refined iron material to produce a limited variety of iron and steel products. In general, the mini-mills are smaller, newer, and more efficient in producing their limited product mix. They are also much more profitable and financially sound. Analyses based on data for the industry as a whole are dominated by the condition of the integrated companies, but the problems revealed are generally not those of the rapidly growing and very profitable mini-mill companies. The mini-mill companies are estimated to have generated about 3 percent of total industry output in 1960 and nearly 20 percent in 1980.

BACKGROUND

Reduced Steel-Intensity. Although world consumption of steel has increased six-fold since World War II, U.S. consumption of steel grew only moderately from 1945 to 1966, and has grown very slightly since. Consumption of steel tonnage in the U. S. from foreign and domestic sources was only 12 percent higher in 1979 than it was a decade earlier; the total consumed in the 1975-1979 period was only 5 percent higher than in the 1965-1969 period. Steel is a less important component of the economy today than it was in the 1960's because of the substitution of other materials for steel and because steel-intensive products have become proportionally less important. The ratio of steel consumed to real GNP fell from a high of 108 tons per million dollars of real GNP in 1965 to 54 tons per million in 1983.

Growth in Import's Share. The value of steel imports has increased substantially over the post-war period; in current dollars, from less than 2 percent of total new supply in 1958 to 15 percent in 1981. From the late 1950's to the early 1970's, imports moved up in step fashion in the last year of each 3-year labor contract. Imports were stimulated when the industry was on strike and when inventories were being built in anticipation of a strike. Moreover, they did not return to their previous levels when new contracts were signed. Almost 85 percent of the increase in imports from 1958 to 1980 occurred in the final year of labor contracts.

Post-1977 Industry Re-structuring. The steel industry can be characterized as having been in a state of quasi-permanent recession since 1966. The 1979 output peak was well below the 1974 peak and below the 1966 and 1969 peaks as well. The 1974 peak was artificial in that it was the result of a temporary export and inventory-building boom created by earlier price controls and their expected removal. If the 1973-74 production peak is removed from consideration, the output trend has been systematically downward since 1966. Following the 1974-75 recession, and bolstered by the protracted period of recession and stagnation which started in 1980, steel producers began a process of "economic rationalization" of their operating practices. Since 1977 roughly 200 production facilities have been closed, and steelmaking capacity reduced from 160 million tons to 135 million tons. Employment levels were cut by more than 40 percent, and the "Big Steel" companies adopted a much tougher bargaining stance with respect to labor compensation and work rules. Under the 1984 industry-wide contract, for example, the United Steelworkers agreed to a reduction in compensation growth to a 1.3 percent compound annual rate over 41 months, compared with the 11 percent annual growth of the 1970's contracts.

Restructuring of the major corporate entities has been another feature of this rationalization process: in 1984, the Justice Department approved the merger of LTV's Jones and Laughlin Steel division with Republic Steel, thereby combining the third and fifth largest U.S. producers; and in April, 1985, Wheeling-Pittsburgh Steel instituted a Chapter 11 Bankruptcy Code filing, following 3 years of uninterrupted losses. In May, 1985, the "Big Steel" companies finally declared an end to industry-wide labor bargaining, a move which is expected to force more competition among producers to cut labor costs but which could leave the companies vulnerable to selective strikes.

Protection From Imports. In 1984 the steel import share of the U.S. market rose to 26 percent, and the industry filed with the International Trade Commission for relief. In response, the Reagan Administration announced a 5-year voluntary restraint program designed to lower that share to 18.5 percent, and give the industry "breathing room" to modernize and increase their cost-competitiveness.

TECHNOLOGY

In 1958, roughly 91 percent of the raw steel produced in the U.S. was made by the **open hearth** process, a technology in use since the turn of the century. This process is expected to account for only 6.4 percent of steelmaking during 1985, having been largely replaced by the **basic oxygen** process. A typical basic oxygen furnace can make 300 tons of steel in 45 minutes, compared with one to seven hours required by other processes.

The use of the **electric arc furnace** for producing raw steel has increased dramatically since 1958, from 3 percent to 28 percent; as mini-mills and many specialty steel mills rely solely on this technology. Sometime in the 1990's, nearly 40 percent of the nation's raw steel is expected to come from the electric arc furnace. The electric arc furnace uses scrap steel or iron pellets instead of liquid metal, and permits steel to be manufactured in smaller plants that are not associated with a blast furnace complex.

Beneficiation and **pelletization** -- crushing, grinding, and concentrating rock of low iron content into high grade iron ore pellets -- represent important technological advances in steelmaking. Currently over 70 percent of iron ore consumed is pelletized.

Another innovation is the direct reduction of iron ore, which converts ore to iron without the high temperatures used in blast furnaces and coke ovens. This method is undergoing rapid expansion in nations with abundant natural gas supplies, since gas is the simplest fuel used in direct reduction; the technique has had only limited use in the U.S., however.

An especially important and cost-saving innovation in steelmaking is the **continuous caster**, which incorporates many of the steps required in the conventional steelmaking process; it reduces scrap costs and requires smaller amounts of raw steel, manpower, and energy per ton of finished steel than the ingot system. In 1984, the "conticast" proportion of raw steel production reached 35 percent, and is expected to reach 40 percent in 1985.

The integrated steel producers have been slow in adopting these new steel-making technologies. This is partly the result of a historically noncompetitive U.S. market, and partly due to the large financial losses experienced by many parts of the domestic steel industry in recent years. In contrast, many U.S. competitors expanded their domestic steel industries and readily adopted new steelmaking technologies.

FACTORS OF PRODUCTION

Capital Investment. Real gross investment for the industry was at about the same level in the late 1970's as in the late 1950's. When investment in pollution abatement is taken into account, real net productive capital stocks -- stocks devoted to the actual production of steel -- have declined nearly $2.4 billion since the early 1970's. Also, the average age of both steel plant and steel equipment is much greater than that of all manufacturing and the proportion of the stock aged five years or less had by 1981 declined to the lowest levels in the postwar period.

Rate of Return And Cost of Capital. The industry has been in increasingly difficult financial straits. The rate of return on capital in the steel industry has declined substantially and has averaged less than one-half the rate of return in all manufacturing since 1958. This has decreased internal funds available for investment, forced growing reliance on external financing, and increased the proportion of funds devoted to servicing and repayment of long-term debt. As a result, the integrated producer's cost of debt capital is well above the average corporate bond rate and its composite cost of capital is well above the industry's own rate of return on capital. In contrast, the "mini-mill" sector of the industry has a higher rate of return and lower capital costs than the integrated producers and a higher rate of return on capital than all manufacturing from 1972 to 1980. The generally depressed period since 1979 offers a dramatic illustration of the financial dichotomy in the U.S. steel industry: between 1979 and 1983 the integrated sector of the industry earned a negative 0.2 percent after-tax rate of return, compared with a positive 7.7 percent earned by mini-mills and 8.4 percent earned by manufacturing overall.

Labor. Since 1966, each business cycle peak found steel industry employment at a lower level; this trend accelerated between 1979 and 1984, as the employment level dropped 40 percent, and 200 thousand steel industry jobs were lost. Unit labor costs declined from 1958 to 1966, at an average annual rate of -0.3 percent; rose from 1966 to 1974, at a 6.0 percent rate; then accelerated to a 13.2 percent rate from 1974 to 1979. A major factor in the growth of total labor compensation has been the rapid increase in fringe benefits. Supplemental payments rose from 10 percent of total compensation in 1958 to 23 percent in 1980. An especially steep climb in labor compensation began in 1971 with the "Voluntary Restraint Agreement" (limiting imports from Japan and the EEC countries) and was boosted further in 1973 with the "Experimental Negotiating

Agreements" which guaranteed workers a 3 percent annual wage increase, cost-of-living adjustments, and productivity bonuses in return for a no-strike pledge. In 1980 the industry average compensation for production workers was $17.01 per hour worked; the comparable figure for all-manufacturing was $9.28.

Energy. The steel industry was affected by the sharp increases in energy prices beginning in 1973, but the severity of the shock relative to other manufacturing industries was mitigated by the fact that petroleum products are relatively less important and that the industry owns much of its coal and coke producing facilities. The industry has changed from predominantly open-hearth to basic oxygen technology and the mix of fuel inputs has changed as well, but coke and breeze still account for more than half of fuel inputs. Although the proportions of electricity and natural gas have risen, the industry energy price index has risen less rapidly than that of all manufacturing. Nonetheless, energy efficiency, measured as the reciprocal of BTU's per unit of real product, has declined over the 1958-1980 period and especially in the 1970's, mainly as a result of reduced output levels and the lack of capital formation. Steady, high levels of output are most conducive to maintaining and improving energy efficiency in the steel industry.

Materials. Materials efficiency, defined as the reciprocal of the real value of materials input per unit of output, rose moderately from 1958 to 1964, then began a series of downward movements to 1980. The reasons for this deterioration in materials efficiency are not completely clear, but the evidence suggests that declining quality of ores, rapidly rising ore prices, and changing technology led the industry to substitute scrap and more highly processed iron bearing materials for less refined ores. About 70 percent of input ore is now lower grade taconite that is refined and concentrated before use. Also, the basic oxygen furnace uses a higher percentage of scrap than does the open hearth and scrap is the primary input for the electric arc furnace -- the basic technology of the mini-mills. Thus the trend is towards more highly processed input materials that embody more labor and energy.

Input Substitution Patterns. The industry's three peak-to-peak intervals -- 1959-66, 1966-74, and 1974-79 -- witnessed distinctly different input substitution patterns. During the first interval cheap energy and materials prices, coupled with low utilization rates, saw the industry greatly increase it use of energy and materials relative to depreciable capital and production workers.

During the second interval, however, the prices of all noncapital inputs accelerated sharply, but the unit prices of production workers and energy led the way by advancing at rates of 8.1 and 13.0 percent, respectively. These circumstances, coupled with a reduction in the benefits of economies of scale due to a dramatic slowdown in output growth (from 4.4 percent during 1959-66 to 1.6 percent during 1966-74), forced the industry to invest heavily in new cost-saving capital; between 1964 and 1969 the industry experienced the only net investment boom it enjoyed between 1958 and 1980. As a result, the industry's use of capital and associated nonproduction labor relative to production labor grew at compound annual rates of 1.1 and 2.0 percent, respectively, between its 1966 and 1974 output peaks, compared with only 0.2 percent per year for both inputs between the 1959 and 1966 peaks. These capital investments also reduced the peak-to-peak growth in the industry's use of energy relative to capital, from 2.4 percent to 0.9 percent per year, and reduced the growth in its use of materials relative to capital, from 1.9 to 1.5 percent per year.

During the 1974-79 interval, the unit prices of labor inputs inflated at double-digit rates and exceeded the growth rates in the prices of all other inputs, including energy and capital. While the economic incentive to increase the rate of investment in labor-saving capital was clearly present, the industry was unable to do so because of declining output (output declined at an average annual rate of 3.8 percent during the 1974-79 peak-to-peak interval) and its rapidly deteriorating financial health. The industry thus continued to substitute capital, energy, and materials for production labor, but at rates one-half to two-thirds of the rates of the 1966-74 period.

PRICES, PRODUCTIVITY, COSTS

Between 1958 and 1966, the productive efficiency of the steel industry compared favorably with other manufacturing industries. Total factor productivity grew at a 1.8 percent annual rate compared with 1.2 percent for all manufacturing. Its cost of production declined at an average annual rate of 0.4 percent between its 1959 and 1966 output peaks, compared with growth rates during comparable peak-to-peak periods of 0.5 percent for all manufacturing. Similarly, the productivity growth derived from its four input categories--capital, labor, energy, and materials--compared favorably with the growth found in all manufacturing through 1966. More importantly, there was a balance between the growth in productivity derived from labor and non-energy materials and the growth in prices paid for these two largest input categories.

After 1966, the growth in steel's economic efficiency, like that of other U.S. manufacturing industries, was adversely affected by a combination of repeated business recession shocks--in 1967, 1969-71, 1975-77, 1980, and 1981; by energy and/or materials price shocks in 1973, 1974, 1979, and 1980--and by general inflation since 1966. While these post-1966 shocks were a common experience for U.S. manufacturing industries, their effect on the steel industry appears to have been more intense and long lasting. Steel's total factor productivity declined at a -0.1 percent annual rate from its 1966 to its 1974 output peaks; it declined at a -0.8 percent annual rate from 1974 to 1979. The comparable figures for all manufacturing were +1.0 percent and +0.6 percent.

In general, the four-input efficiency performance of the U.S. steel industry has, like its output growth performance, lagged behind that of other U.S. industries since 1966; and especially so since 1974. But, it has been particularly out-of-line with respect to labor. Unit labor costs in the steel industry have increased at a 12.0 percent average annual rate of growth since 1974, 4.9 percentage points higher than in all manufacturing. Simply put, the problem is that growth in labor compensation has lost its historic relationship to growth in labor productivity since 1966. In fact, since 1974 they have been moving in opposite directions--labor compensation per employee advancing at the average annual rate of 10.5 percent and labor productivity declining at a 1.5 percent rate.

THE DECLINE OF INTEGRATED STEEL

The decline of the U.S. steel industry has been the decline of its integrated segment; indeed, the mini-mill segment has experienced strong profits and continued growth, capturing markets from both the domestic-integrated segment and foreign steel producers. The difference between the two sectors of the industry can be largely attributed to mini-mills use of more efficient and cheaper steelmaking technologies (electric arc furnace and continuous casting); to the employment of a flexible, nonunion workforce; to a more harmonious labor-management relationship, based on the widespread use of employee productivity incentives -- employee involvement, training, and profit-sharing programs; and to the urban location of plants, close to both their major raw material (scrap) and their customers.

Factors contributing to the integrated segment's decline are:

1. The changing composition of the U.S. economy--away from goods-producing and steel-intensive industries towards service producing industries;

2. The more frequent business cycles and high inflation rates since the mid-1960's;

3. The loss of steel markets to domestic substitutes for steel, e.g., plastics and aluminum, and to domestic mini-mills;

4. The loss of steel markets to foreign steel producers.

Of these four factors, the first two are clearly exogenous to the steel industry, but the third and fourth are arguably the result of the declining competitive posture of integrated steel. That is, they were the result of rising unit costs, declining production efficiency, and rising relative prices.

The industry had considerable market power in the 1950's, 1960's, and even in the 1970's. Although the integrated companies have earned below average rates of return since 1958, production workers earned a 40 percent premium over compensation paid to their counterparts in all-manufacturing from 1959 to 1966 and that premium increased to nearly 80 percent by 1980. Similarly, nonproduction workers in steel, earned a 24 percent premium over compensation paid to their all-manufacturing peers during 1959-66 but earned a 43 percent premium during 1979-80. Thus, if the industry's **markup** is defined to include both returns to capital and the premium paid to workers, it is clear that the mini-mills, the foreign producers, and the producers of substitute materials had abundant opportunities to move into the traditional markets of integrated steel. 1/

The growth of imports has also been facilitated by the 3-year bargaining cycle (between the United Steel Workers and the integrated companies) that existed prior to 1973. Steel imports first became a significant factor in the U.S. during the 119 day strike of 1959 and nearly 85 percent of the growth in steel imports from 1958 to 1980 occurred in the third years of the bargaining cycle. Even when settlement occurred without a strike, the steel buyers' desire to protect against expected shortages led to the increased purchase of foreign steel. These increases in imports moved upward in a rachet-like manner because the increases before and during the bargaining period were not reversed after settlement. The Experimental Negotiating Agreement was intended to solve this problem, but it was ineffective and labor compensation grew at an 11 percent annual rate following its introduction in 1973.

Reflecting the distribution of the markup, the integrated companies have earned below-average profits and have experienced an after-tax rate of return on capital that has been less than half the all-manufacturing average since 1966. As a consequence, integrated steel producers were forced to turn increasingly to debt financing, became increasingly leveraged, and were forced to pay more for new capital. Their cost of new capital averaged 1 percent point more than the industry's overall rate of return from 1966 to 1974 and that shortfall widened to an average 3.2 percentages points from 1974 to 1979. The higher cost of capital increased unit costs of production, reduced the industry's ability to invest in new cost-saving technologies, and made other investment

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1/ This concept of markup over "normalized" costs is discussed in PART III: Section B.1.

opportunities (e.g., oil and banking) more attractive to the integrated steel companies themselves. The integrated steel sector was caught in a downward spiral that grew persistently worse.

OUTLOOK

Free-world steel consumption is expected to grow by about 20 million tons by 1990, but free-world steel production capacity is expected to remain about the same or increase slightly. Thus, excess capacity will remain the 120 to 135 million ton range that existed in 1980. This chronic imbalance has led some industry observers to forecast that U.S. raw steel capacity will be at the 100 million ton level by 1990, compared with its present 135 million ton level.

All of this reduction, and more, will come from the integrated mill segment of the industry; the mini-mill segment is expected to grow and to account for about 40 percent of U.S. capacity in the 1990's. But the production efficiency and competitiveness of the surviving integrated producers should be much improved over its 1980 or 1985 state. Restructuring, consolidation, labor "give-backs," and large scale investment in competitive with domestic mini-mills and foreign integrated steel producers. If so, this would make integrated steel producers' prospects better than in many years.

PART I

SUMMARY OF MAJOR TRENDS
IN THE
U.S. PRIMARY IRON AND STEEL INDUSTRY
SINCE 1958

A. THE CHANGING STRUCTURE OF THE U.S. PRIMARY IRON AND STEEL INDUSTRY

A.1 The Industry At-A-Glance

Definition: The domestic steel industry is defined here as Standard Industrial Classification (SIC) code 331, and includes establishments which operate blast furnaces and steel mills, and those which produce steel wire, electrometallurgical products, and steel pipes and tubes. Based on 1982 shipments, the four largest companies in the industry were U.S. Steel, Bethlehem Steel, Jones and Laughlin Steel (LTV), and National Steel.

Types of Producers: Integrated. In integrated plants, iron ore, limestone, and coke are converted into steel through a series of processing steps which include the production of pig iron, raw steel, and steel mill products.

Non-integrated. These companies operate melting and casting units and rolling mills, and produce a limited range of products for a limited market, using scrap metal as the raw material.

Mini-mills generally are small producers with capacities a little less than one-half million net tons per year, and have much more limited product lines than integrated companies.

Specialty companies are also generally small, but have a much larger number of specialized products and grades or alloys.

Products: Carbon Steel. Because of their much lower cost and the ease with which they can be formed and welded, carbon steels dominate industry production. By weight, carbon steels accounted for an estimated 86 percent of total raw steel production in 1982, according to the American Iron and Steel Institute (AISI). Machines, auto bodies, most structural steel for building, and ship hulls are among the products made from carbon steel.

Alloy Steel. These steels contain specified proportions of vanadium, tungsten, molybdenum, or other elements, and larger amounts of manganese, silicon, and copper than carbon steel. The major markets for alloy steels are the auto, construction, industrial machinery and equipment, and electrical equipment industries. The greater strength, corrosion-resistance, and special electrical attributes of alloy steels have contributed to the development of these major markets. By weight, alloy steels represented more than 12 percent of total steel production in 1982.

Stainless Steel. Attractive in appearance and highly resistant to rust and corrosion, stainless steels accounted for nearly 2 percent of total steel volume in 1982. Certain stainless grades have unusual strength and can withstand extreme temperatures; such attributes have led to their growing use in the aerospace industry. The other leading markets include consumer durables, the petrochemical and food processing industries (where they are used for pipes and tanks), and the medical field (where they are used for surgical instruments and equipment).

Selected Steel Industry Data

	1959	1966	1974	1979	1983
Shipments (Bill. 72$)	24.377	32.493	37.604	30.958	15.900[a]
Net Productive Capital Stock (Bill. 72$)					
Plant	10.757	10.834	10.512	9.256	n/a
Equipment	10.137	12.371	14.010	14.479	n/a
Employment (Thousands)	579.5	637.9	611.0	544.4	310.2[a]
Production Workers	476.0	522.7	486.0	433.3	229.3[a]
Nonproduction Workers	103.5	115.2	125.0	111.1	80.9[a]
Compensation per Production Worker Hour	$3.69	$4.48	$8.61	$14.81	$22.21[e]
Corporate Profits (Bill. $)	0.65	0.85	2.40	1.87	-2.95
Rate of Return on Book Value of Capital Stock	4.6%	4.6%	7.8%	5.0%	-5.5%
Total Energy Products Consumed (Bill. 72$)	2.367	3.104	3.378	3.215	n/a
Total Materials Consumed (Bill. 72$)	11.943	15.158	20.010	16.248	n/a
Input Productivity: (1972=100)					
Capital	95.8	118.3	132.5	119.2	n/a
Labor	79.0	97.9	116.2	107.6	98.2[e]
Energy	104.3	108.6	118.3	106.5	n/a
Materials	104.7	112.4	96.9	98.4	n/a

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a = Values taken from **U.S. Industrial Outlook, 1985.**
e = estimate.

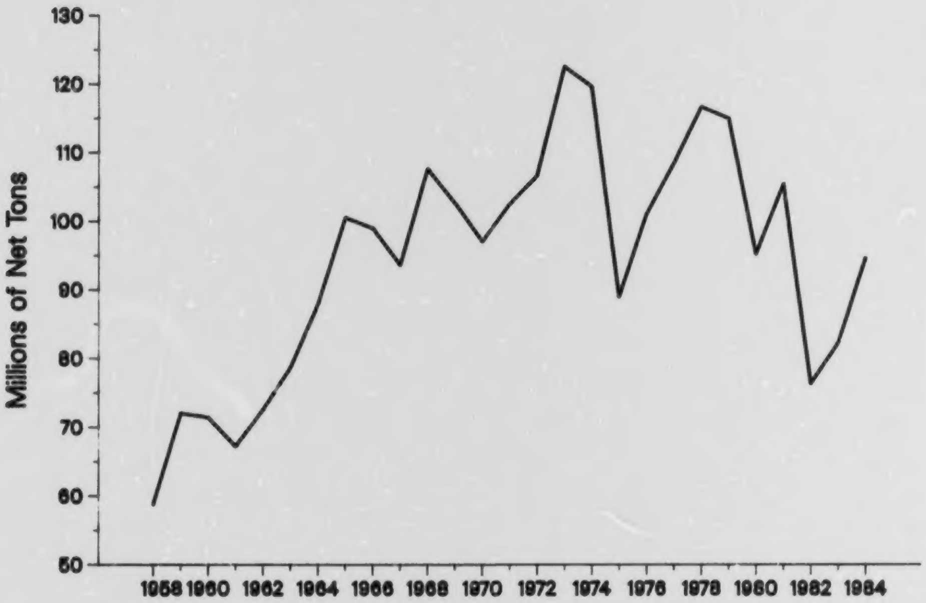
SOURCE: Standard & Poor's Compustat Services, In., Office of Business Analysis, U.S. Department of Commerce; and **U.S. Industrial Outlook 1985**, International Trade Administration, U.S. Department of Commerce.

A.2. Changes in Domestic Consumption Patterns Since 1958

All sectors of the economy use steel in one form or another and are likely to continue to do so in the future; indeed, technological improvements in various types of specialty and alloy steels are expected to increase their application throughout the economy. Nevertheless, the U.S. apparent consumption of steel (product shipments plus imports minus exports) has been declining since its 1973 peak of 123 million net tons, as shown in Figure 1.

FIGURE 1

U.S. Apparent Steel Consumption, 1958-83
(Millions Of Net Tons)



SOURCE: American Iron and Steel Institute.

This decline in apparent steel consumption has occurred at the same time that real GNP has grown from 1.3 trillion dollars in 1973 to 1.6 trillion dollars in 1983. The annual rates of change of apparent steel consumption were 2.4 percent from 1966 to 1974 and -3.7 percent from 1974 to 1980; the comparable real GNP annual growth rates were 3.0 percent and 2.8 percent. This shows that the consumption of steel in the U.S. economy has significantly declined relative to real GNP over the past two decades (Figure 2). Indeed, relative steel consumption was reduced by more than half between 1965 and 1983, falling from over 108 tons per million dollars of real GNP to nearly 53 tons. This gradual trend away from steel has contributed significantly to the decline of the domestic steel industry in the United States.

TABLE 1

U.S. Apparent Consumption Of Steel Products Vs. Real GNP, Selected Years

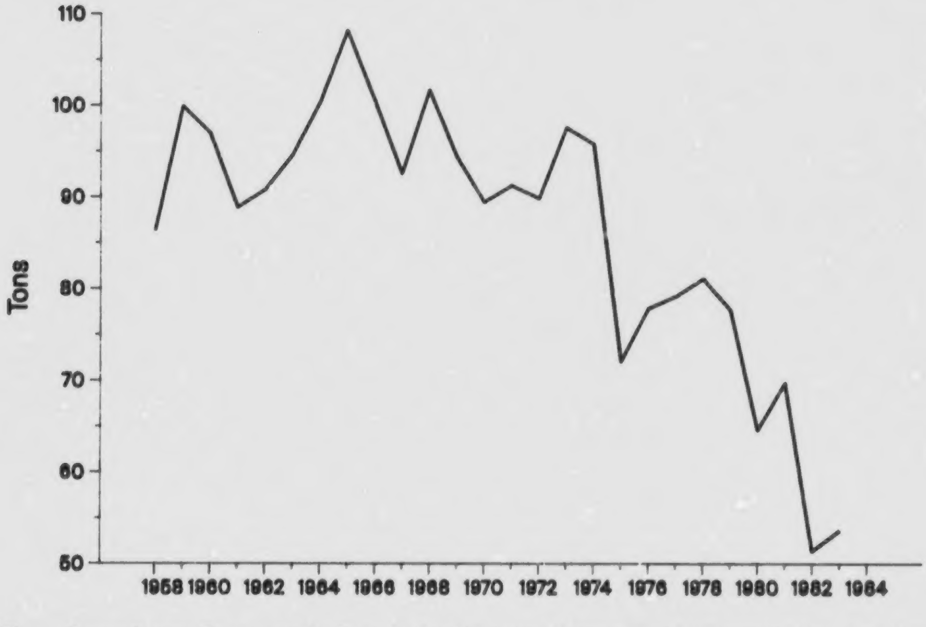
Year	GNP (Billions of Constant 1972$)	Consumption a/ (Thousands Of Net Tons)	Apparent Steel Apparent Steel Consumption To GNP (Net Tons Per Million 1972$)
1959	721.7	72,096	99.9
1966	984.8	99,024	100.6
1974	1,246.3	119,609	96.0
1979	1,479.4	114,962	77.7
1980	1,475.0	95,247	64.6
1981	1,512.2	105,444	69.7
1982	1,480.0	76,388	51.6
1983	1,534.7	82,300	53.6
1984	1,639.3	94,700	57.8

a/ Apparent Consumption equals product shipments plus imports and minus exports.

SOURCE: Bureau of Economic Analysis, U.S. Department of Commerce; and American Iron and Steel Institute.

FIGURE 2

U.S. Steel Consumption To GNP Ratio, 1958-83
(Tons Per Million 1972 Dollars Of GNP)



SOURCE: American Iron and Steel Institute; Bureau of Economic Analysis, U.S. Department of Commerce.

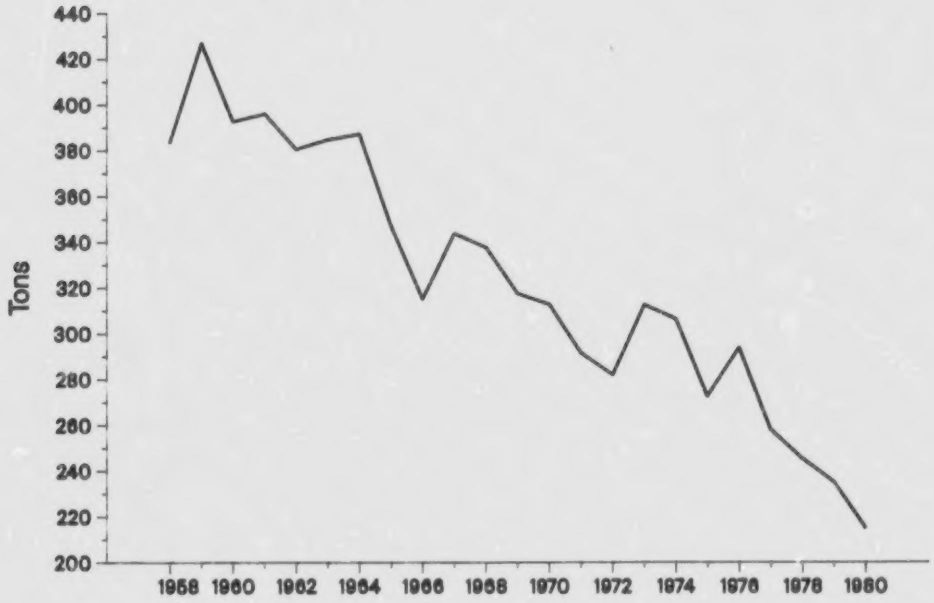
The largest domestic market for steel is the network of steel service centers and distributors. In 1982, 21.2 percent of all domestic steel mill products were channeled through these distributors, according to AISI. The next largest markets are the automotive industry, which consumed 15.1 percent of domestic steel shipments in 1982, and building construction, which consumed 13.9 percent in 1982; the latter is probably the largest steel market when service center steel is reallocated to end users. Other important markets for steel products include equipment and machinery manufacturers (9.5 percent) and containers and packaging materials (7.3 percent).

In 1982, both the automotive and construction markets for steel consumed approximately one-half the amount of steel they consumed in 1974. Major declines in steel consumption have also occurred in the machine tools, containers and packaging, transportation, and oil and gas markets. At the same time, steel imports have grown very rapidly. It should be noted, however, that data on steel consumption do not take into account the steel embodied in other imported products, such as automobiles, auto bodies and parts. If steel embodied in imported products were included in the steel consumption data, the total steel-intensity ratio would be greater than that shown here.

The major reasons for the decline of steel-intensity in the U.S. economy are the substitution of other materials for steel, and changes in the composition of GNP. Rising

FIGURE 3

Steel-Intensity In Motor Vehicles, 1958-80
(Tons Per Million 1972 Dollars Of Output) a/



a/ The numerator excludes the value of imported parts.

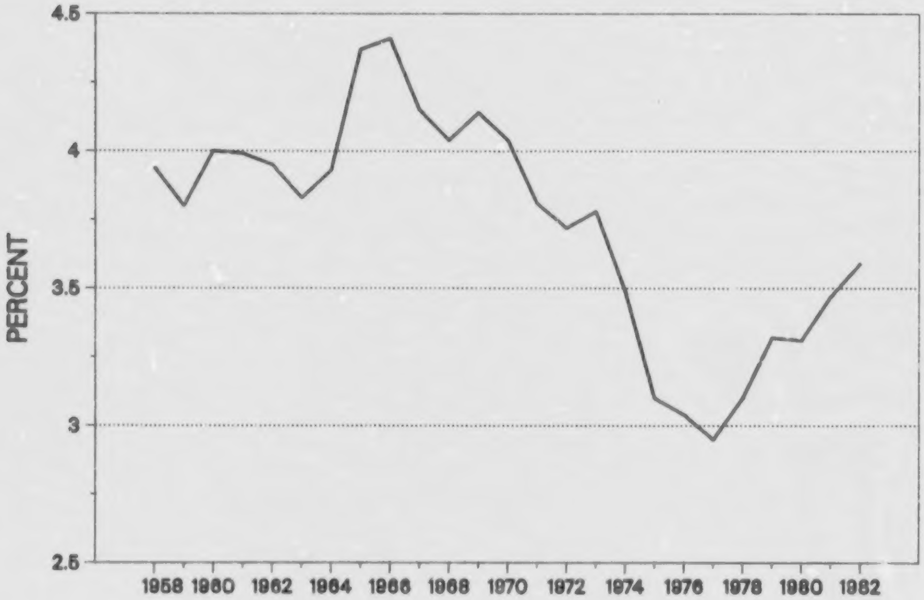
SOURCE: American Iron and Steel Institute; Office of Business Analysis, U.S. Department of Commerce.

costs of energy, for example, precipitated a continuing need for weight reduction in autos and the substitution of other materials such as aluminum and plastics for steel. In 1958, the steel-intensity of automotive products was 384 tons per million dollars of real output measured in constant 1972 dollars; by 1980, it had declined to 215 tons per million dollars of real output (see Figure 3).

There has also been a significant shift in product composition favoring the less steel-intensive sectors of the economy. For example, the service industry, which as a whole is not considered to be steel-intensive, represented 42 percent of GNP in 1958. By 1982, however, the service sector had expanded to nearly 48 percent of GNP. At the same time, some of the major steel-intensive sectors have failed to keep pace with GNP growth. For example, non-residential construction, which is a major consumer of steel, represented 4.4 percent of GNP in 1966 (Figure 4). By 1977, its share had dropped to less than 3 percent and then recovered somewhat to 3.6 percent in 1982. Furthermore, even though gross private domestic investment in producers durable equipment as a whole increased faster than GNP over the entire 1958-80 period, many of its steel-intensive components such as machine tools showed relatively slower rates of growth, especially in more recent years.

FIGURE 4

Investment In Nonresidential Structures
As A Percent Of GNP, 1958-82

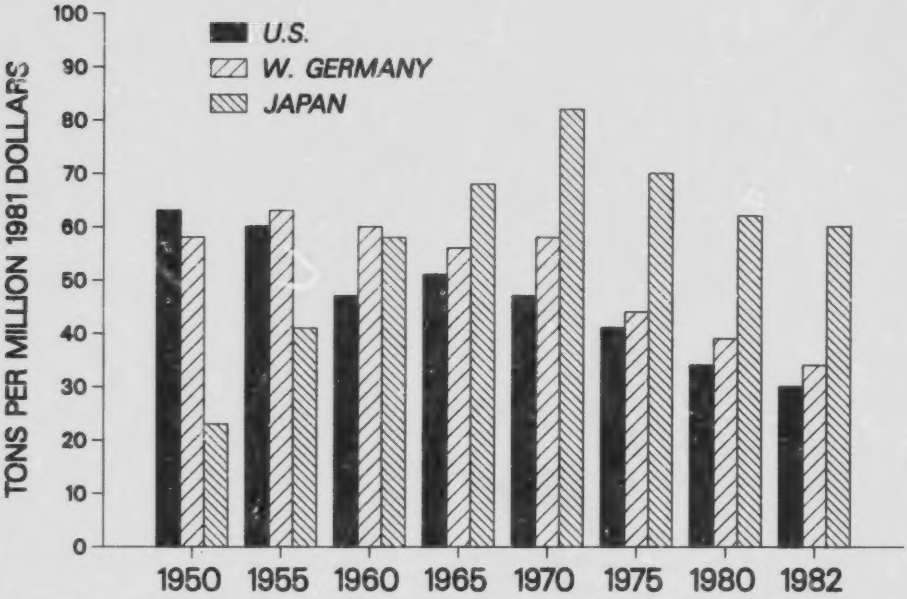


SOURCE: Bureau of Economic Analysis, U.S. Department of Commerce.

This trend of declining steel-intensity is not unique to the U.S., as Figure 5, below, shows; research by a number of international steel industry analysts shows that as a country matures past the full commercialization phase of its industrial revolution, the majority of the primary industrial infrastructure has been built (e.g., manufacturing plants, cities, roads, dams, etc.), causing steel-intensity per dollar of GNP to decline

FIGURE 5

Intercountry Comparison Of Steel-Intensity



SOURCE: Barnett and Schorsck, **Steel: Upheaval In A Basic Industry.**

from that point. Another factor is increasing per capita income rising to a level developed countries where consumers demand products which involve lower steel content. These peak intensity points seemed to have occurred in the U.S. around 1950, in advanced Western European economies in the mid and late 1950's, in the U.S.S.R. and the Eastern European nations in the early 1960's, and in Japan in the early 1970's.

Thus, apart from the problem of imports to be discussed in the Section C below, the steadily declining steel-intensity of the U.S. economy offers one important clue of a secular nature to the declining fortunes of the U.S. steel industry. Another may be attributed to the inability of the U.S. steel industry to capture a greater share of the expanding world market (Figure 12).

A.3. Recent Events And Their Impact On The Industry

Historically, steel production has followed the business cycle, since large amounts of steel are used in the highly-cyclical construction and capital goods industries, and in consumer durables such as automobiles and appliances. The impact of the recent world-wide recession on the domestic steel industry has been particularly severe, however. Between 1981 and 1982, raw steel production dropped 9 percent world-wide, but production in the United States plummeted 38 percent, according to AISI. The import share of domestic steel consumption rose rapidly over the same period, from 18 percent in 1981 to 26 percent by Autumn, 1984. The United States last led the world in steel production in 1973, the same year U.S. steel consumption peaked; in 1974, the U.S.S.R. became the leading producer of steel. Since 1980, the United States and Japan have been competing for the second place position.

In 1983 and 1984, the steel industry recorded only modest improvement from its disastrous 1982 experience of low output, high unemployment, and large financial losses. Production and shipments improved modestly but significant losses continued, although at a slightly lower rate. Mini-mills, however, reported modest operating profits. Moreover, the industry as a whole was still operating at only 55 to 60 percent of capacity -- too low to break even and well below historical standards -- though the industry's extensive cost-cutting of recent years has reportedly reduced its break-even operating rate from 80 percent to 65 percent.

The Process Of Economic Rationalization Began In 1977...

In the euphoria over the rising prices and profits produced by the 1973-74 worldwide boom in steel demand, the domestic steel industry's integrated mills were predicting in 1975 that they would need to add 25 million tons of capacity over the next five years to their existing capacity of approximately 155 million tons 1/. By 1977, however, the underlying uncompetitive cost structure of the industry became apparent; a more realistic assessment of the industry's future growth prospects was in order, in light of the return of steel imports to an 18 percent share of the U.S. market from a 12 percent share in 1974. At this point the industry initiated the first of several profound steps to rationalize both its production process and the size and number of its antiquated operating establishments, as well as its employment and compensation practices. The need for this rationalization was unequivocally confirmed by the protracted period of recession and stagnation which began in 1980 and which, in 1985, shows no signs of abating.

...But Accelerated After 1979.

Since 1977 and especially since 1979, the 10 "Big Steel" companies, which comprise the bulk of the integrated mill sector of the U.S. steel industry, have closed or liquidated approximately 20 obsolete and unprofitable plants entirely or in part; some 200 facilities have closed industry-wide. 2/ As a result, raw steelmaking capacity has been reduced from 160 million tons in 1977 to 151 million tons at the beginning of 1983, and to 135 million tons in late 1984, with a further 5 percent reduction expected in the near future. The overall industry has pared its employment rolls by more than 40 percent, from 540,000 in 1979 to 314,000 in 1984.

Jones/Laughlin And Republic Steel Merger In 1984: Likely The First Of Several.

Included in this rationalization process was the first of what was expected to be several large-scale mergers among the "Big Steel" integrated steelmakers. In 1984, the Justice Department approved the merger of LTV's Jones and Laughlin Steel division with Republic Steel, thereby combining the 3rd and 5th largest U.S. producers. However, a proposed merger of the largest producer, U.S. Steel Corporation, with the 6th largest producer, National Steel Corporation, was withdrawn when it became evident that Justice Department approval was unlikely without a significant divestiture of facilities by the proposed consolidated company.

Management Adopts A Tougher Approach To Controlling Labor Costs...

Another important dimension of this rationalization effort is the much tougher and more independent stance adopted by management in each of the 10 Big Steel companies, with respect to negotiating labor compensation and union work rules. This new aggressiveness has also produced the first significant company- and plant-specific departures from industry-wide, collective bargaining agreements and from the

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1/ See "Steel's Not-So-Solid Expansion Plan," **Fortune**, January 1976.

2/ See "Time Runs Out For Steel," **Business Week**, June 13, 1983 and; "Capacity Cuts Helpful but...", **Industry Surveys**, Standard and Poor's, Oct. 25, 1984, p. 19.

longstanding practice of allowing U.S. Steel Corporation set the terms during industry-wide bargaining with the United Steel Workers Union.

...Forcing Labor Givebacks...

Under the March 1, 1984 industry-wide contract, for example, the Union agreed to an unprecedented reduction in labor compensation. Hourly labor costs under the agreement were expected to drop from about $24 per hour in 1983 to $22 per hour in 1984, then rise to $25 per hour by August 1986, when the contract expires. While this agreement did not go as far as management wanted nor as far as most industry observers feel is necessary to avoid further wide-scale layoffs, it nevertheless reduces the growth in hourly labor costs to a compound rate of 1.3 percent per year over the 41-month life of the contract, compared with growth of more than 11 percent per year during the 1970's. 3/

...And Increasing The Competition Between Plants.

In addition, several companies have used the threat of selected plant closings to win local settlements that were even more advantageous both in terms of lower compensation rates and in the relaxation of restrictive work rules and manpower requirements. As management has sought to weed out inefficient plants, to consolidate production in its most efficient plants, and husband its limited capital by modernizing only its most promising plants, inter-plant competition has sometimes developed, forcing workers at one plant to compete with those at other plants for survival. 4/

Industry-Wide Bargaining Begins To Collapse.

For nearly 30 years, the large integrated steel producers have bargained as a unit with the United Steel Workers, always in lock-step behind U.S. Steel Corporation. The industry's present problems, however, have forced several companies to consider leaving the fold; National Steel announced its intention to do so in August of 1984, and Inland Steel and Armco are considered likely to follow.

The end of the industry-wide bargaining unit is expected to have profound effects on both sides of the bargaining table. It is likely to force more competition among producers to cut labor costs, end U.S. Steel Corporation's role as the primary decision-maker on contract terms for the rest of the industry, and could leave the companies vulnerable to selective strikes. For union leaders, it threatens to undercut the central control they currently enjoy, since companies will focus their bargaining efforts on the leaders of the union locals at individual plants rather than on the union's international officers. 5/ This process, as described above, is likely to force plant workers to improve productivity and lower wage costs or risk closure as each company consolidates operations in its most efficient plants.

1985 Wheeling-Pittsburgh Bankruptcy Filing: Short-Term Pain But Long-Term Benefit.

The demise of industry-wide bargaining can be expected to accelerate in the wake of the April 16 (1985) Chapter 11 Bankruptcy Code filing by Wheeling-Pittsburgh.6/

3/ See references in Note 2.

4/ See, e.g., C. Hymowitz and A.F. O'Boyle, "Two Steel Mills Gird for Result of Merger Bid," **Wall Street Journal**, February 22, 1984, p. 35 and C.E. Mayer, "Bethlehem Steel to Modernize in Md., Ind.," **Washington Post**, July 1, 1983, p. C9.

5/ See T.F. O'Boyle and C. Hymowitz, "Steel Industry's Bargaining Group Appears to be on Verge of Collapse," **Wall Street Journal**, August 3, 1984, p. 19.

Since 1978, the nation's seventh largest steelmaker spent over $700 million on world-class steelmaking technology -- a rate 40 percent higher than Japanese producers and nearly twice that of U.S. producers overall. But, nearly 3 years of uninterrupted losses (the company has not yet filed a complete FY-84 Income Statement), totaling $122 million since 1982, made it impossible to support the $514.6 million in long-term debt used to finance this investment. However, the company's state-of-the-art technology, coupled with the debt reorganization and large labor cost concessions it is expected to obtain under the bankruptcy reorganization, will make it a low cost producer among U.S. integrated companies. As a result, industry analysts expect Wheeling's bankruptcy to increase the already intense price competition among U.S. integrated steelmakers; this places more pressure on the other companies to pursue their own survival interests in labor negotiations with the United Steelworkers, in an attempt to match Wheeling-Pittsburgh's overall cost advantage. Wheeling's bankruptcy filing could thus prove to be a singularly important catalytic event in the overall process of rationalizing the integrated sector of the U.S. steel industry, instigating perhaps dramatic improvements in both its financial health and competitiveness.

Integrated Mills Begin To Retrench Towards Great Lakes Area.

In an effort to reduce the cost of transporting both their raw material and finished products, the integrated companies have begun to concentrate their operations in the Greak Lakes areas of Michigan and Illinois, closer to both their primary source of iron ore and to their biggest customers -- chiefly the motor vehicles and heavy equipment industries. Toward this end, the bulk of their plant closings have been in Pennsylvania, Ohio, and Indiana. 7/

1984 Export Restraint Agreement.

The most recent development in the industry occurred in September, 1984 when President Reagan announced a 5-year voluntary restraint program designed to lower the market share of imports to 18.5 percent and give the industry "breathing room" to modernize and become more cost-competitive. The details of this and earlier steel industry programs are summarized in Table 2.

In the opinion of most industry analysts, the earlier episodes of government protection cited in Table 2 were counterproductive to both the industry and the overall economy. Denzau, for example, states:

> The results from all these efforts to protect the American steel industry were predictably disappointing. The industry raised its prices; steel prices rose 33 percent faster than all industrial products during 1970-77. The union succeeded in raising wages (at more than 11 percent per year), and the U.S. ended the decade behind the Japanese technology. 8/

7/ See A.T. Denzau, "American Steel: Responding to Foreign Competition," **Center For The Study Of American Business**, No. 66, February, 1985.

8/ See reference in note 6, p. 15. Also see L. Kiers, **The American Steel Industry: Problem, Challenges, Perspectives**, Boulder, Co: Westview Press, 1980, and R.W. Crandall, "The Roots of the Current Crisis in the U.S. Steel Industry: An International Perspective," in H.R. Williams (ed) **Free Trade, Fair Trade, and Protection: The Case of Steel**, Kent, OH: Kent State University Press, 1978, pp. 46-47.

TABLE 2

A Long History Of Government Protection

1968: Imports reached 18 percent of domestic production; to forestall congressional action, Japanese and EEC countries agreed to 3-year Voluntary Export Restraint (VER) agreement, limiting shipment to the U.S. to 4.75 million tons each in 1969, with an allowed 5 percent a year growth thereafter.

1972: Non-quota countries -- e.g., the United Kingdom, Korea, Brazil and Spain began filling the void left by the 1968 VER, and EEC and Japan rapidly substituted high-value uncontrolled specialty steel products for controlled products, causing widespread domestic industry dissatisfaction with the 1968 VER. The 1972 agreement is much more detailed than 1968, includes U.K. and explicitly limits specialty steel imports.

1977: Following 1975 world-wide recession, imports again reach 18 percent of U.S. market in 1977. Carter administration responds with Trigger Price Mechanism (TPM). Trigger Price is defined as Japanese unit cost plus 8 percent profit on sales. Foreign countries are prohibited from selling steel in U.S. below the Trigger Price.

1984: Industry dissatisfaction with TPM prompts industry to file with International Trade Commission for relief. In July, 1984 ITC proposes a 15 percent import quota on all sources of foreign steel. In September, Reagan Administration rejects 15 percent import quota recommendation in favor of seven separately negotiated VER agreements with Argentina, Brazil, Japan, Korea, Mexico, South Africa and Spain. These combined with already existing agreements with Canada and the European Common market Countries were expected to reduce the steel import share of the U.S. market to 18.5 percent from 26 percent. However, several observers estimate the decline will be only to 22.5 percent. The period of restriction is 5 years and expires in 1990.

SOURCE: Arthur T. Denzau, "American Steel: Responding to Foreign Competition," **Center For The Study of American Business**, No. 66, Feb., 1985, and Stuart Auerbach, "President's Dilemma On Steel," **Washington Post**, Aug., 1984, p. G1.

Denzau predicts that the new program will cost American consumers $5 billion annually and produce no benefits to the economy. "Big Steel's gains will likely result in far greater losses for American's steel-using sectors. To add insult to injury one-third of the dollars ($5 billion) . . . will go to foreign steel firms." 9/

Steel, Kent, OH: Kent State University Press, 1978, pp. 46-47.

9/ See reference in note 6, p.1 and p. 17. Also see Effects of Import Quotas on the Steel Industry, Congressional Budget Office, July 1984; H. Rowen, "A Bailout's High Cost," **Washington Post**, August 19, 1984, p. G1; and T.F. O'Boyle, "U.S. Consumer Is Seen as Big Loser In New Restraints on Imported Steel," **Wall Street Journal**, January 7, 1985, p. 27.

B. TRENDS IN TECHNOLOGY

B.1 Integrated Mills And Mini-Mills

Since 1958, the U.S. primary iron and steel industry has become increasingly dichotomized into two distinctly different classes of firms: integrated mills and mini-mills. 10/ The former consist primarily of the 10 well known large companies that make up what is known as "Big Steel" 11/. In comparison, the mini-mill segment of the industry is composed of a much larger number of companies, most of which are relatively small and unknown. 12/ Between 1958 and 1960, there were 10 to 12 mini-mills in the U.S. and these accounted for about 3 percent of domestic steel production. By 1984, however, their number had increased to 50 and their share of production had grown to some 20 percent. The 1985 share is expected to reach 24 percent, and to peak between 32 and 40 percent by 1995.

The basis of this dichotomy is found in the very different production technologies employed by integrated mill companies compared with mini-mills. These differences are outlined in Figures 6 through 10. The production process of the integrated steel producer begins with iron ore in the ground and ends with finished steel products in a large variety of shapes and sizes (Table 3). As such, integrated companies generally mine their own iron ore and often the coal and limestone; prepare and integrate these materials in a blast furnace complex to produce pig iron; convert the pig iron to steel ingots or slabs in a steel making furnace -- open hearth, basic oxygen or electric arc; and transform the ingots and slabs into a full range of finished steel products and shapes in a rolling mill complex consisting of soaking pits, reheating furnaces, breakdown mills, and finishing mills (Figure 6). In the 1970's, few integrated companies were equipped with continuous casters, which have been a standard feature of mini-mills for 15 years. However, those mills so-equipped have eliminated the soaking-pit, reheating furnace, and breakdown mill components of the rolling mill complex. Since World War II, only two completely integrated mills have been built in the U.S., and those plants, using the older open-hearth process instead of basic oxygen or electric are furnace, were considered obsolete by 1960.

10/ Background for this section was taken from: J.B. Miller, "Steel Mini-mills," **Scientific American**, Vol. 250, May 1984, pp. 33-39; Standard & Poor's **Industry Surveys**, October 25, 1984, pp. 19-24; A.T. Denzau, "American Steel: Responding to Foreign Competition," **Center For the Study of American Business**, No. 66, February, 1985; and "Technological Change and Manpower Trends in Five Industries," Bulletin 1856, 1975, pp. 21-33, and "Technical Trends In Major American Industries," Bulletin 1474, February, 1966, pp. 68-76, U.S. Department of Labor, Bureau of Labor Statistics.

11/ These include (by size of 1983 U.S. market share): U.S. Steel Corp. (16.7%), Bethlehem Steel Corp. (12.9%), Jones & Laughlin Steel Corp. (8.6%), National Steel Corp. (6.0%), Republic Steel Corp. (7.1%), Armco, Inc. (6.4%), Inland Steel Co., Inc. (7.1%), and Wheeling-Pittsburgh Steel Corp., Cyclops Inc., NVF Corp.

12/ The biggest mini-mill company, Nucor Corp., however, is now the tenth largest steel maker in the country.

TABLE 3

Raw Steel To Finished Products: A Glossary of Terms

Molten steel from basic oxygen, electric and open hearth furnaces flows into ladles and then follows one of two major routes to the rolling mills that form most of the industry's finished products. Both processes produce solid semifinished products -- one, ingots; the other, cast slabs. The terms below are presented in the order they appear in the production process.

Raw steel: Molten (unshaped and unrolled) steel.

Ingot: A large steel shape, formed when molten steel is poured (teemed) into an ingot mold to solidify. The ingot is later reheated and rolled into a semi-finished steel shape such as a billet, bloom, or slab.

Semi-finished steel: Steel shapes such as billets, blooms, or slabs that are later rolled into finished products.

Billet: A square or rectangular semi-finished piece of steel that is later rolled into a finished product such as a bar.

Bloom: A square or rectangular semi-finished piece of steel (larger than a billet) that is later rolled into a finished product such as an I-beam or other structural shape.

Slab: A semi-finished steel product (wider than a bloom) that is later rolled into a finished product such as a sheet.

Bar: A shaped steel product available in many configurations, including rounds, squares, ovals, hexagons, and rectangles.

Sheet: A flat-rolled finished steel product. Sheet is wider (12 inches or more in width) and produced to less exact thicknesses than strip, a similar flat-rolled product.

Strip: A flat-rolled steel product. Strip is narrower (12 inches or less in width) than sheet and produced to more closely controlled thicknesses.

Plate: A finished steel product, flat rolled like sheet, but heavier and thicker. Plate is used extensively in the construction and heavy machinery industries.

Alloys: Metallic substances added to steel to enhance properties such as machinability or heat resistance.

Carbon Steel: Steel whose properties depend chiefly on its carbon content and microstructure (as opposed, for example, to alloy steels, which depend on alloying elements for their enhanced properties). Carbon steel accounts for the largest percentage of steel produced worldwide.

Specialty steels: Steels such as stainless, heat resisting, and toolsteels, produced in small volumes to meet specialized needs.

Toolsteel: Steel that can be hardened and tempered for use in making tools and dies.

Electrical steel: Steel in which silicon and other additives minimize energy loss in electrical power applications.

Flat rolled: Steel rolled on rolls with smooth faces (as compared to the grooved or cut faces used to roll structural or shaped products). Common flat rolled products include sheet, strip, plate, black plate, and tin plate.

Cold rolling: Rolling steel without first reheating it. Cold rolling reduces thickness, produces a smooth surface, and makes it easier to machine.

Hot rolling: Rolling steel after it has been reheated.

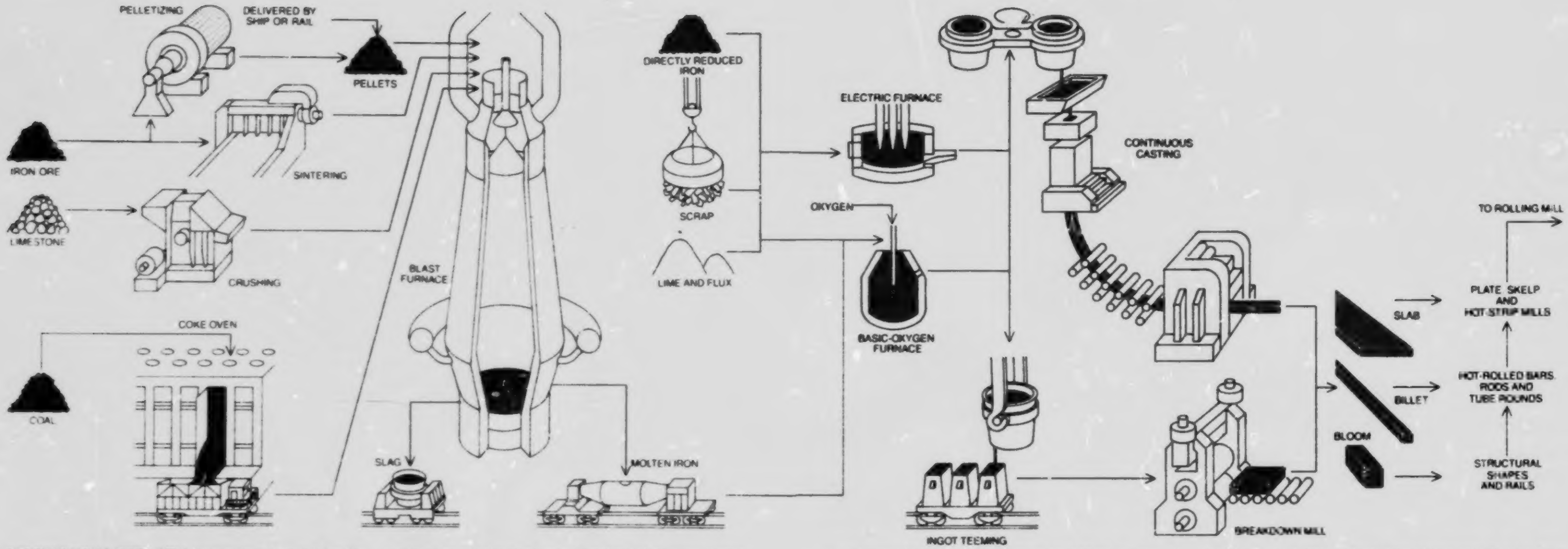
Annealing: Heating and then cooling steel to improve its formability and make its surface more durable.

Galvanized steel: Steel coated with a thin layer of zinc to increase its corrosion resistance.

SOURCE: Standard & Poor, **Industry Surveys,** October 25, 1984.

FIGURE 6

Steelmaking Technology: Integrated Steel Mill Operation


PELLETIZING
DELIVERED BY SHIP OR RAIL
PELLETS
IRON ORE
SINTERING
LIMESTONE
CRUSHING
COKE OVEN
COAL
BLAST FURNACE
SLAG
MOLTEN IRON
DIRECTLY REDUCED IRON
SCRAP
LIME AND FLUX
ELECTRIC FURNACE
OXYGEN
BASIC-OXYGEN FURNACE
CONTINUOUS CASTING
INGOT TEEMING
BREAKDOWN MILL
SLAB
BILLET
BLOOM
TO ROLLING MILL
PLATE, SKELP AND HOT-STRIP MILLS
HOT-ROLLED BARS, RODS AND TUBE ROUNDS
STRUCTURAL SHAPES AND RAILS

CONVENTIONAL STEEL MILL is termed an integrated plant because it begins with iron ore and ends with finished or semifinished steel products. Mixtures of lump ore and pellets (and perhaps sinter), sized limestone and coke are charged together into a blast furnace to make pig iron. In the refining step the objective is to remove carbon from the iron to make steel, which has a carbon content of 1.7 percent or less. Pig iron, scrap, lime and fluxes are put into a steelmaking furnace (the two types depicted are an electric-arc furnace and a basic-oxygen furnace), where carbon, manganese and silicon are removed or reduced to specified levels by controlled oxidation and where contaminants such as phosphorus and sulfur are also removed. The steel is cast into ingots, which are broken down into slabs, billets or blooms that then go to a rolling mill to be shaped into products. Large integrated steel mills are increasingly installing continuous slab-casting machines to replace the ingot-mold procedure. An integrated plant has more extensive operations and makes more steel than a minimill.

SOURCE: "Steel Mini-mills" by Jack Robert Miller, Copyright 1984 by Scientific American, Inc.

Mini-mills are so named not because they are necessarily small but because they encompass only a small portion of the steel-making process and capital investment of the typical integrated firm and they provide only a narrow range of steel products (Figure 7). A comparison of Figures 6 and 7, for example, shows that, unlike the typical integrated mill, the mini-mill has no blast furnace complex and, therefore, no investment in materials (iron ore, coal, coke, and limestone) stockpiles and storage facilities; in rail and other materials transporting facilities; coke ovens; or in limestone crushing and iron ore sintering and pelletizing plants. Mini-mills are able to eliminate all of these investments because their basic raw material is scrap metal instead of iron ore.

Moreover, unlike integrated mills, where the basic oxygen furnace is the dominant steelmaking furnace, the electric arc furnace technology is used by all mini-mills (Figure 9); and continuous casting (Figure 10) is the rule in the mini-mill production process but the exception in integrated mills. As a result, mini-mill companies routinely achieve an additional substantial capital investment savings in the finished steelmaking portion of their production process through the elimination of the soaking pit, reheating furnace and breakdown mill facilities found in the rolling mill complex of most integrated mills (compare the electric furnace and basic oxygen furnace production streams in Figure 6).

Integrated mills require substantial economies of scale to reduce per ton production costs to competitive levels. As a result, most integrated U.S. mills have been built to produce from 3 to 10 million metric ingot-tons per year, compared with approximately 250,000 tons for the typical U.S. mini-mill. However, the range of U.S. mini-mill capacity extends from upwards of 600,000 tons per year to as low as 50,000 tons.

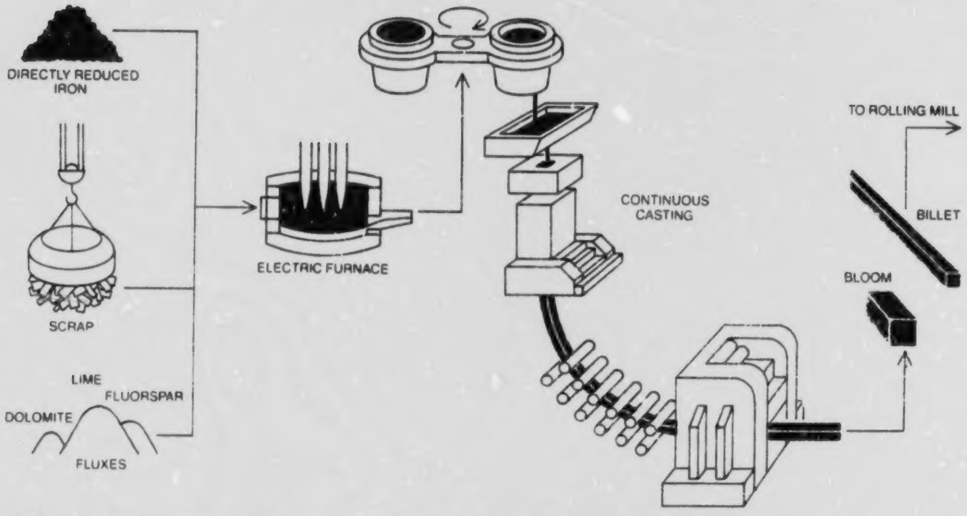
The electric arc furnace technology also produces major energy and transportation cost savings for mini-mills compared with integrated mills. The electric arc furnace consumes only about one-third the amount of energy per net ton of steel production that the blast-furnace, basic oxygen operation of the typical integrated mill consumes -- 5.32 million B.T.U's versus 16.08 million B.T.U's. And, because of their relatively small size, most mini-mills are located in urban areas close to their product and materials markets, resulting in a considerable savings in shipping costs. In contrast, the location of most integrated mills has been largely determined by the railroad network and the Great Lakes ore deposits.

Finally, mini-mills also have significantly lower unit labor costs than integrated mills. Mini-mills generally employ nonunion labor and rely heavily on profit sharing, training, promotion, and employee involvement programs to maintain good relations with workers and avoid the intensely adversarial labor-management relationship that has long been characteristic of "Big Steel". It is estimated that the total employment cost per metric ton of steel product shipped varies between $60 and $100 a ton at mini-mills, compared with $195 to $295 a ton at integrated mills.

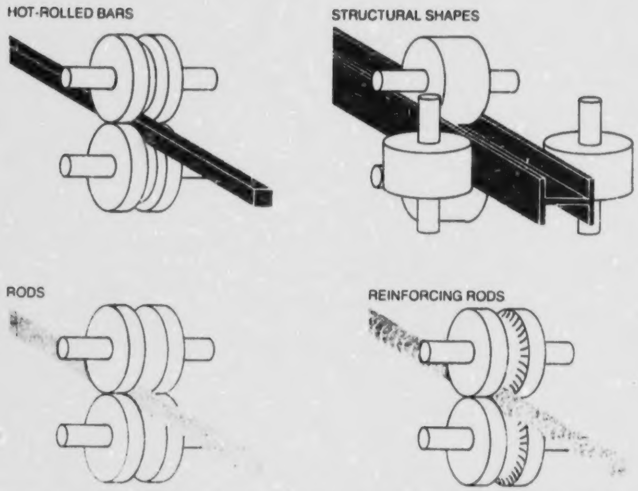
Together these cost advantages make the U.S. mini-mill sector, unlike the integrated mill sector, very competitive with foreign producers (Figure 3). Nevertheless, the proportion of U.S. integrated mill capacity which can be displaced by mini-mills is estimated to be limited to between 32 and 40 percent of total U.S. production. **This limit is the consequence of an often overlooked fact: Mini-mills are, in the final analysis, heavily dependent on the integrated mills. Indeed, without the scrap metal derived largely from the products of integrated mills, it is estimated that mini-mill production would cease in less than 10 years.**

FIGURE 7

Steelmaking Technology: Mini-Mill Operation And Products


DIRECTLY REDUCED IRON
SCRAP
LIME
FLUORSPAR
DOLOMITE
FLUXES
ELECTRIC FURNACE
CONTINUOUS CASTING
TO ROLLING MILL
BILLET
BLOOM

MINIMILL OPERATION dispenses with the ironmaking steps of the conventional steel plant and begins with steel scrap, flux and (occasionally) directly reduced iron. The scrap is melted in an electric furnace, poured into ladles and transferred to a continuous-casting machine. From the casting machine the steel emerges as a continuous billet or bloom that is cut off at suitable lengths and sent into the rolling mill, where usually only a few products are made. They include rods and bar and structural shapes for light construction. Over the past 10 years a few minimills have expanded their line of products to include such items as pipe, plate, narrow strip and narrow sheets.


HOT-ROLLED BARS
STRUCTURAL SHAPES
RODS
REINFORCING RODS

PRODUCTS OF MINIMILLS include bars, rods, smooth and deformed reinforcing rods and light structural shapes. The bar forms include flats, rounds and squares (named for their cross-sectional shape). In some plants the product is rolled into bar form and then drawn into wire.

SOURCE: "Steel Mini-mills" by Jack Robert Miller, Copyright 1984 by Scientific American, Inc.

B.2 Specific Technologies And Their Diffusion

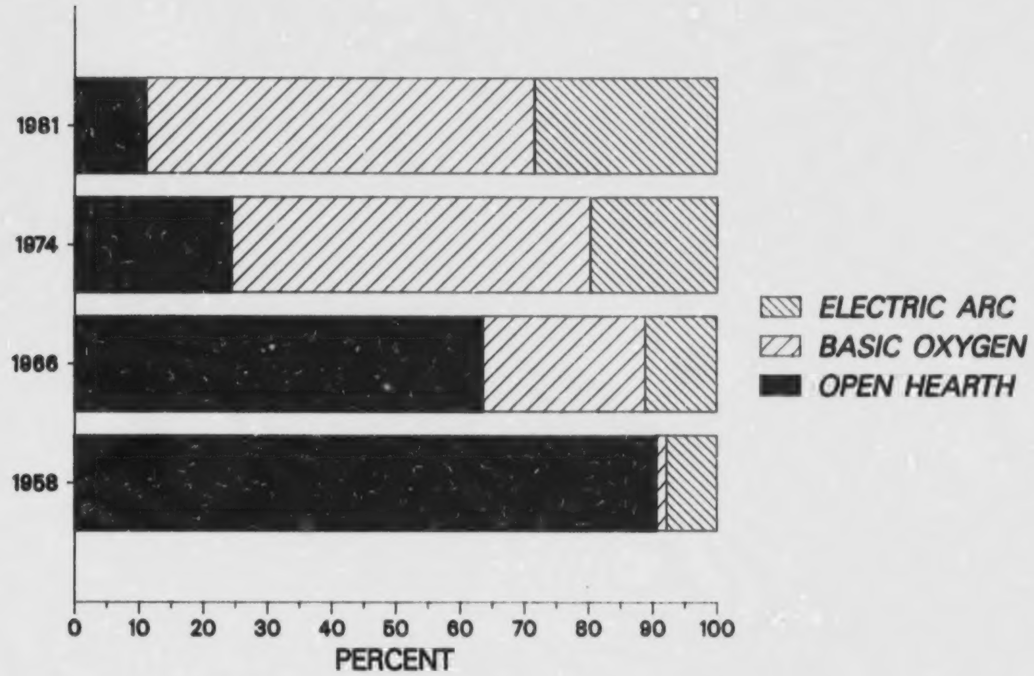
Major technological developments in U.S. steelmaking since 1958 include: replacement of the open-hearth process by the basic oxygen process for the production of raw steel, increasing use of the electric arc furnace, beneficiation and pelletization, direct reduction of iron ore, and continuous casting. Each of these will be discussed briefly below.

The **open-hearth process** has been used to produce raw steel since the turn of the century. In an open-hearth furnace, hot molten iron, some scrap steel, and limestone are charged in a shallow steelmaking area known as a "hearth" which is "open" to flames, alternating from opposite ends of the hearth. The AISI estimates that in 1958 roughly 91 percent of the steel produced in the United States used this method of production (See Figure 8). It accounted for only 11 percent in 1981, 7.0 percent in 1983 and is expected to account for 6.4 percent of steel production in 1985. Most open-hearths are now used only as standby furnaces in periods of peak steel demand or when basic oxygen furnaces are temporarily taken off line for repairs.

The open-hearth furnace has been largely replaced by the **basic oxygen furnace** or **BOF** (Figure 6). In 1958, less than 2 percent of all raw steel produced in the United States used the basic oxygen furnace, compared with about 70 percent in Japan. Since then, the U.S. steel industry has steadily increased the proportion of output produced by this method to 25 percent in 1966, 56 percent in 1974, and 61 percent in 1981; the basic oxygen furnace is expected for account for nearly 62 percent of steel production in 1985.

FIGURE 8

Steelmaking Technology: Raw Steel Production By Process

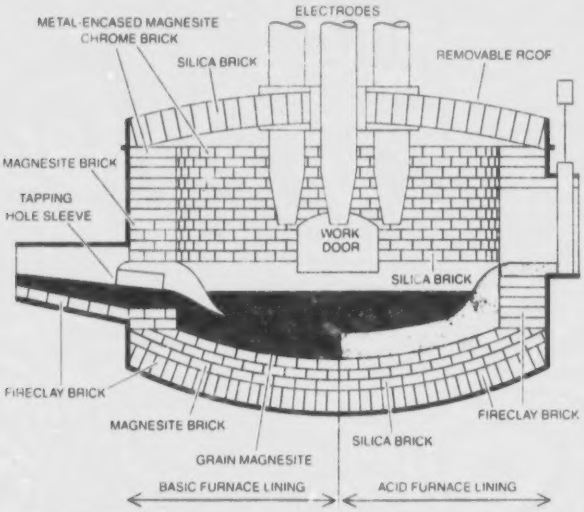


SOURCE: American Iron and Steel Institute.

The basic oxygen process uses molten pig iron from a blast furnace plus scrap metal as primary raw materials. Rapid combustion is provided by oxygen, which is blown in through the roof or fed through the bottom of the furnace. A typical basic oxygen furnace can make 300 tons of steel in 45 minutes, compared with one to seven hours required by other processes.

FIGURE 9

Steelmaking Technology: Electic Arc Furnace



ELECTRIC FURNACE is the central part of a minimill. It can be more than eight meters in diameter and can hold more than 150 metric tons of molten metal. Three graphite electrodes enter through separate holes in the roof. When power is turned on, intense heat is generated in the furnace. Electric arcs are struck from one electrode to pieces of the steel scrap that constitute the metallic charge of the furnace and then are struck from the charge to the next electrode. The charge is melted, forming a metallic bath covered with a layer of slag. The refractory lining differs for basic and acidic practice. In the more usual basic practice the chemical reactions (involving a "limy" slag, magnesite refractories and the hot metal) remove carbon, silicon, manganese, phosphorus and sulfur from the bath and yield molten steel. The roof-and-electrode assembly is moved aside and the furnace is tilted to pour the steel into ladles for casting.

SOURCE: "Steel Mini-mills" by Jack Robert Miller, Copyright 1984 by Scientific American, Inc.

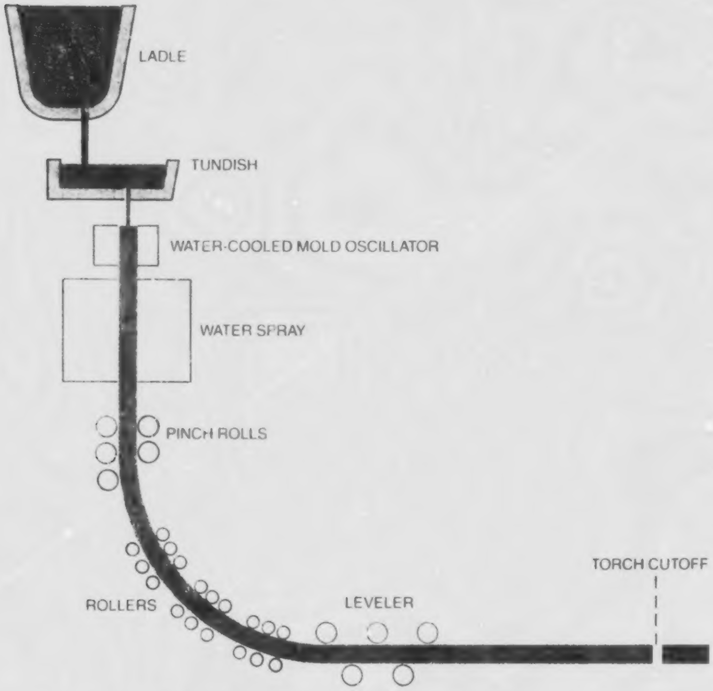
A third method of producing raw steel is the **electric arc furnace** (Figure 9). In 1958, about 8 percent of U. S. steel was produced in electric arc furnaces, but by 1981, this had increased to approximately 28 percent. 13/ This share is expected to reach 32 percent in 1985 and 36 percent or more in 1990. Mini-mills, and some specialty steel producers, rely solely on this steelmaking technology. In an electric arc furnace, the melting of steel is controlled as an electric current arcs from one electrode, through the metallic charge in the furnace, to another electrode. The electric arc furnace uses scrap or iron pellets instead of liquid metal and permits steel to be manufactured in smaller plants that are not associated with a blast furnace complex. These characteristics give mini-mill producers several important cost advantages over integrated mill producers: lower capital investment per ton of steel, shorter plant construction time, lower energy and transportation costs, and flexibility in plant location. The use of scrap steel as the major raw material in an electric arc furnace can result in substantial cost savings, especially when the price of scrap is low.

13/ Including electric arc furnaces owned by specialty steel firms.

Beneficiation and **pelletization** improves the quality and uniformity of iron ore used in blast furnaces. This new technology involves crushing, grinding, and concentrating rock of low iron content into high grade iron ore pellets. For example, taconite ores (which have a relatively low iron ore content) from the mines in the Great Lakes region can be processed into pellets with over 60 percent iron content. During the early 1970's, less than half of the ore consumed was pelletized. By the early 1980's, however, this had increased to over 70 percent.

FIGURE 10

Steelmaking Technology: Continuous Casting



CONTINUOUS CASTING is the standard method of casting in minimills. Molten steel delivered to the continuous-casting operation in a ladle by an overhead crane is poured into the tundish, which acts as a funnel, feeding the liquid into a water-cooled copper mold. The metal and the mold move downward for a short distance, allowing the skin of the steel to solidify. Then the oscillator breaks the mold loose and returns it to the starting position. The strand of steel continues downward through water-sprayed guides. Near the bottom the strand is rolled into a horizontal position. Sections are cut off and sent to the reheating furnace of the rolling mill. A newer practice is to send the strand directly from the casting machine to the rolling mill.

SOURCE: "Steel Mini-mills" by Jack Robert Miller, Copyright 1984 by Scientific American, Inc.

Another innovation is **direct reduction** of iron ore. Direct reduction of iron ore provides an alternative to the blast furnace and coke oven for the production of iron. These processes typically operate at lower temperatures than blast furnaces and convert iron ore to iron without melting. Direct reduction is undergoing rapid expansion, particularly in Third World countries and in nations with abundant supplies of natural gas, which is the simplest fuel for making directly reduced iron. However, direct reduction has had only limited use in the U.S. Several plants using direct reduction of iron ore have recently been closed because of rising natural gas prices.

An especially important, cost-saving innovation is the **continuous caster** (Figure 10). Many of the steps included in the conventional steelmaking process, including ingot teeming, striping, soaking, and certain preliminary rolling steps are eliminated in continuous casting. Molten steel is carried in a ladle directly to the top of the caster from the open-hearth furnace, basic oxygen furnace, or electric arc furnace. After the molten metal is poured, it is fed into the caster where it then flows outward or downward in a continuous ribbon of solidifying steel. The steel is then moved in the horizontal plane where it is cut to lengths for rolling. Compared with conventional ingot casting, continuous casting is a much more efficient process and produces a higher quality steel. It reduces scrap costs and requires roughly 15 to 20 percent less raw steel per ton of finished steel, 10 to 15 percent less time and manpower, and 40 to 50 percent less energy than the ingot system for producing the same amount of finished steel. In 1982 only 29 percent of all the U.S. raw steel production was "conticast", up from 22 percent in 1981. Since then, 16 new continuous casters with an aggregate capacity of 16 million tons of conticasting capability has been added to the 27 million tons that existed in 1981. In 1984, the conticast proportion of raw steel production reached 35 percent and is expected to reach 40 percent in 1985.

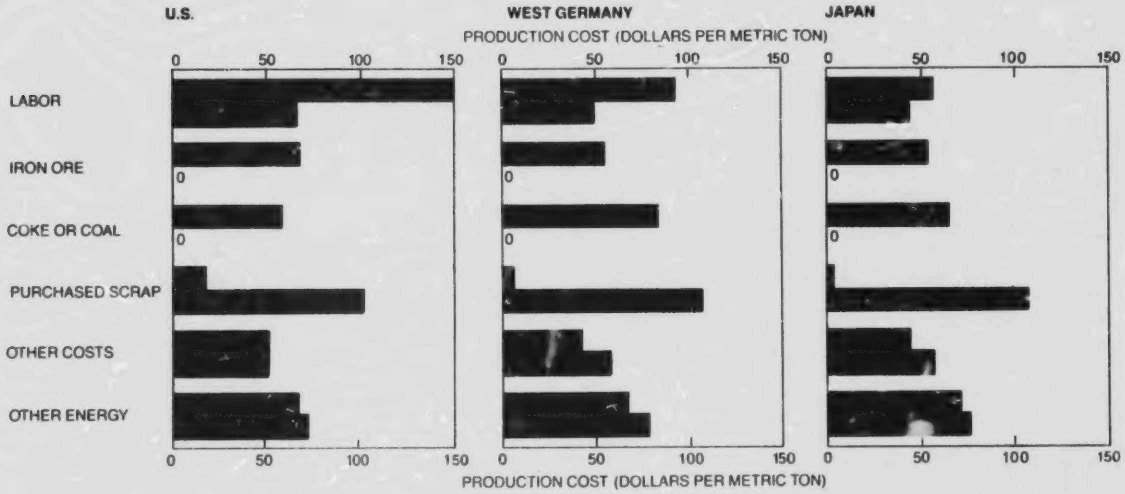
The U.S. Industry Has Been Slow To Adopt Cost-Saving Technologies.

Compared with its major competitors in the world market, the integrated mill sector of the U.S. iron and steel industry has been slow in adopting newer and more efficient steelmaking technologies. For example, while nearly all 1973 steel production in Japan came from BOF or electric arc plants, only about 60 percent of U.S. production did. By 1984, however, the percentage grew to over 90 percent. Similarly, only an estimated 30 percent of domestic steel was produced by continuous casting in 1981, against nearly 80 percent in Japan and over 50 percent in Europe. More extensive continuous casting is estimated to provide the Japanese with a 10 percent advantage over most U.S. integrated mills in finished steel product obtained per ton of raw steel consumed. The Japanese obtain 0.91 tons of finished steel products per ton of raw steel, compared with 0.83 tons in the U.S. However, the domestic steel industry has made major gains since 1981 in some technologies, such as its adoption of electric arc furnaces and continuous casting to produce raw steel. The proportion of electric arc furnace steel is now estimated to be comparable with that of Japan and greater than that of many European countries. The effect of this technological tardiness on the cost competitiveness of the integrated mill segment of the U.S. steel industry vis-a-vis mini-mills, compared with their European and Japanese counterparts, is quite apparent in the relative cost data shown in Figure 11.

The slower adoption of some major steelmaking technologies in the United States is, in part, the result of a historically noncompetitive U.S. market; and of the large financial losses experienced by many parts of the domestic steel industry over the past few years when large investments were required to convert from conventional steelmaking methods. Also, the percentage of total U.S. steelmaking capacity using the newer technologies has increased more slowly because the U.S. steel industry reached a mature size before these technologies were developed. Many U.S. competitors expanded their steel industries during this same time period, allowing them to more readily adopt new steelmaking technologies than the United States.

FIGURE 11

Intercountry Comparison Of Steel Production Costs: Integrated Mills Versus Mini-Mills



PRODUCTION COSTS per metric ton for integrated steel mills and minimills in 1981 are compared for the production of wire rods. Under each heading such as labor and iron ore the top bar represents the costs for an integrated mill and the bottom bar represents the costs for a typical minimill. The minimill makes no outlays for iron or coke. Costs such as depreciation, interest and taxes are not shown.

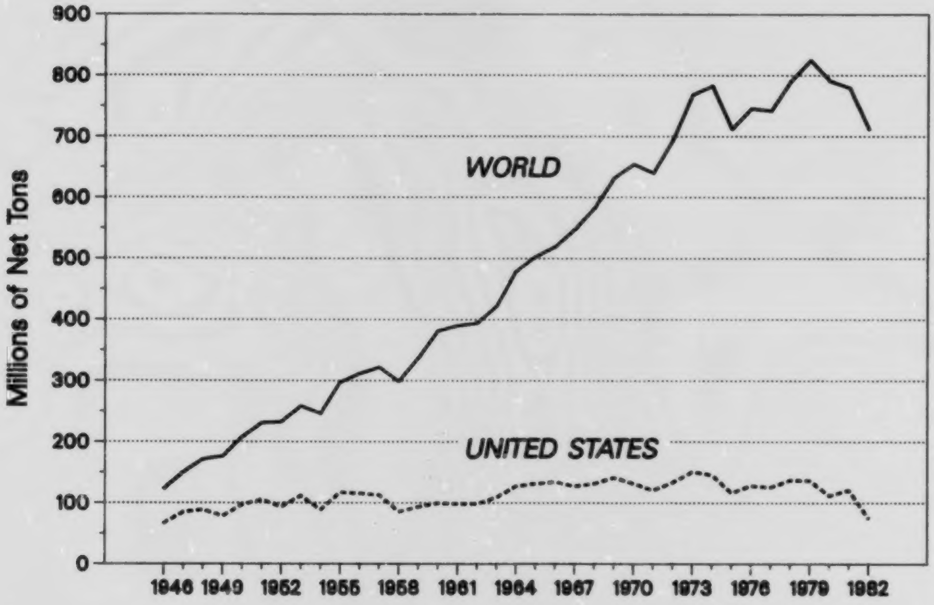
SOURCE: "Steel Mini-mills" by Jack Robert Miller, Copyright 1984 by Scientific American Inc.

C. FOREIGN COMPETITION

Following World War II, the United States was the undisputed leader in world steel production. In 1946, the United States produced more than half of the world's raw steel (Figure 12). As Japan, Europe, and the Soviet Union began rebuilding their industries, which had been destroyed by war, the United States lost its dominant position in steel production. By 1958, the U.S. share of total world production of steel fell to 29 percent. As Japan and Third World countries aggressively expanded their steel production levels, the U. S. world share declined further to 16 percent in 1981 and 10 percent in 1982. The world steel production expanded nearly sixfold between 1946 and 1979, but U.S. production grew only modestly.

FIGURE 12

World And U.S. Steel Production, 1946-82
(Millions Of Net Tons)



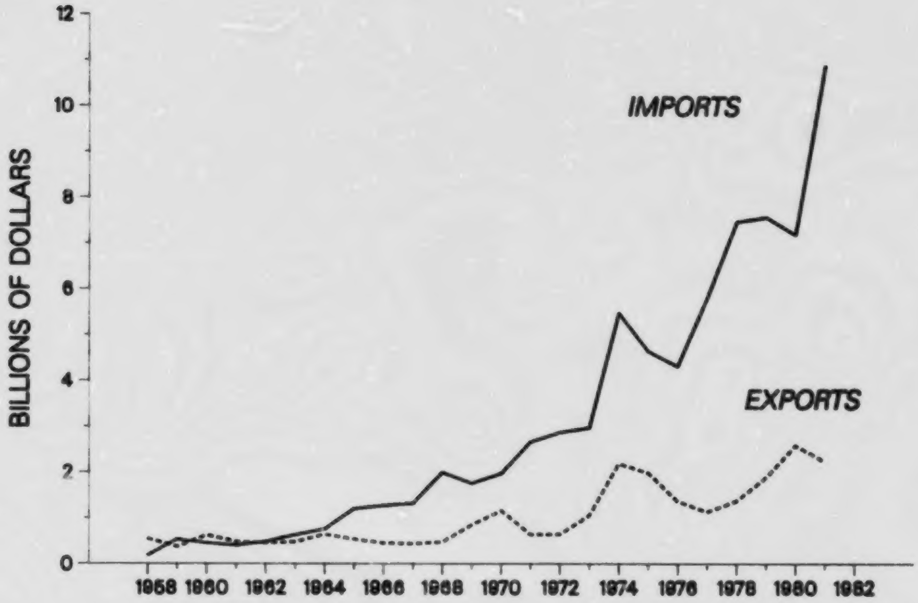
SOURCE: American Iron and Steel Institute.

The domestic steel industry did not share in the rapid growth of the world steel market after World War II. Since 1958, the United States has exported between two and five percent of its steel production, while the percentage of steel imports (measured as the ratio of U. S. imports to total new supply in current dollars) has increased from about 1 percent in 1958 to nearly 15 percent in 1981. Moreover, the percentage of steel imports measured in tons rose from nearly 3 percent in 1958 to 18 percent in 1981 and to 21 percent by 1982, according to AISI. By late 1984, 26 percent of the total new tonnage of steel available in the United States was imported.

Although world raw steel production in tons increased 138 percent from 1958 to 1982, domestic production declined by nearly 13 percent over the same period. The declining role of the U.S. steel industry in the domestic and international markets is reflected in substantially increased U. S. steel imports and relatively flat export levels over most of this period (Figure 13).

FIGURE 13

Steel Exports And Imports, 1958-81
(Billions Of Dollars)



SOURCE: International Trade Administration, U.S. Department of Commerce.

U.S. steel exports have not shared in the rapidly expanding world steel market over the past few decades. In 1958, exports of steel mill products were 2,823 thousand net tons. By 1974, steel mill product exports had increased by 107 percent to a peak of 5,833 thousand net tons. Exports declined to 2,904 thousand net tons in 1981 and 1,842 thousand net tons in 1982. Measured in net tons, exports of steel mill products were approximately 3 percent of domestic shipments in 1981 and 1982, compared with nearly 5 percent in 1958. Measured alternatively in current dollars, exports as a share of domestic steel product shipments also remained relatively constant, fluctuating between 2 percent and 5 percent over the 1958 to 1981 period (Table 4).

In contrast, imports of steel mill products increased 1,066 percent from 1,707 thousand net tons in 1958 to a peak of 19,898 thousand net tons in 1981. Imports of steel mill products, measured in net tons, represented over 18 percent of new supply (product shipments plus imports) in 1981 and then increased to nearly 21 percent in 1982; this is compared with less than 3 percent in 1958. Imports as a percent of new supply and measured in current dollars increased from 1 percent in 1958 to nearly 15 percent in 1981 (Table 5).

Significant increases in imports typically occurred each time the U. S. Steelworkers' contract came up for renewal: 1959, 1962, 1965, 1968, 1971, 1974, 1977, and 1980. Following the 119-day strike by the U. S. Steelworkers in 1959, consumers warily increased their steel inventories prior to each new contract negotiation in anticipation of another lengthy strike. Reliance on foreign producers increased at these times, as

TABLE 4

Steel Exports As A Percent Of Product Shipments, 1958-81 (Exports Measured In Millions Of Current Dollars)

Year	Exports	Exports As A Percent Of Comparable Product Shipments
1958	549.3	3.8%
1959	369.7	2.3
1960	625.7	3.8
1961	479.9	3.1
1962	453.7	2.8
1963	480.3	2.7
1964	644.5	3.3
1965	534.9	2.5
1966	450.9	2.0
1967	441.8	2.1
1968	477.8	2.2
1969	853.3	3.6
1970	1,160.8	5.1
1971	638.5	2.8
1972	648.1	2.5
1973	1,061.0	3.3
1974	2,186.1	5.0
1975	1,983.9	5.3
1976	1,364.3	3.2
1977	1,136.2	2.5
1978	1,379.2	2.6
1979	1,886.2	3.1
1980	2,582.9	4.6
1981	2,229.2	3.5

SOURCE: International Trade Administration, U.S. Department of Commerce.

consumers of steel searched for alternative sources of supply. In fact, the data in Table 5 reveal that of the $6,992.3 million increase in current dollar imports between 1958 and 1980, almost 85 percent can be explained by the increases which occurred just in these contract renewal years. Since 1960, the typical renewal-year increase ranged between 35 and 60 percent, with a high of 84 percent in 1974.

The short-lived euphoria over the worldwide boom in steel demand during 1973-74 led the industry to adopt the Experimental Negotiating Agreement (ENA) to try to terminate the renewal year "rachet effect" on imports. The ENA substituted mandatory arbitration for a potential strike during the 1974 labor contract negotiations and thereafter to 1983. In exchange for the no-strike commitment, the ENA guaranteed workers a three percent wage growth on top of a cost of living adjustment of two-thirds to three-fourths of the Consumer Price index. This, coupled with the rapid inflation of the 1970's, produced a massive runup in wages (see PART II: Section C and PART III: Section B.4 below). And, the 1974 and 1977 import data in Table 5 suggest that the industry's customers remained unconvinced that ENA would solve the problem.

TABLE 5

Steel Imports And New Supply, 1958-81
(Millions Of Current Dollars)

Year	Imports	New Supply a/	Imports As A Percentage Of New Supply
1958	189.5	14,528.1	1.3%
1959	534.9	16,855.0	3.2
1960	456.3	17,000.4	2.7
1961	403.4	16,108.4	2.5
1962	487.7	16,925.7	2.9
1963	634.3	18,293.0	3.5
1964	762.1	20,473.5	3.7
1965	1,205.3	22,869.9	5.3
1966	1,274.5	23,338.8	5.5
1967	1,325.6	22,000.3	6.0
1968	1,994.3	24,232.4	8.2
1969	1,760.8	25,265.3	7.0
1970	1,973.3	24,651.0	8.0
1971	2,663.6	25,778.6	10.3
1972	2,870.8	28,455.4	10.1
1973	2,972.9	35,417.4	8.4
1974	5,468.4	49,493.0	11.1
1975	4,637.2	42,123.9	11.0
1976	4,307.5	46,463.7	9.3
1977	5,790.6	51,653.4	11.2
1978	7,464.7	61,203.2	12.2
1979	7,566.2	68,962.4	11.0
1980	7,181.8	62,836.6	11.4
1981	10,884.1	74,393.0	14.6

---

a/ New Supply = Imports + Product Shipments Base.

SOURCE: International Trade Administration, U.S. Department of Commerce.

A large increase in steel exports compared with imports in 1973 was related in part to the devaluation of the U. S. dollar, combined with Government wage and price controls imposed earlier. The import to new supply ratio dipped from 10 percent in 1972 to 8 percent in 1973, but the ratio of exports to product shipments remained at approximately 3 percent. In 1974, the import to new supply ratio again increased to 11 percent. Over the period from 1974 to 1976, exports as a percent of total product shipments declined from 5 percent to 3 percent, and imports as a percent of new supply dropped from 11 percent to 9 percent.

In 1978, as the imports to new supply ratio increased to 12 percent, a trigger-price mechanism on steel imports was imposed in the United States, barring imported steel at any price below the computed cost in Japan, presumed then to be the most efficient steel producer, plus transport charges, overhead, and a stipulated profit margin. This helped to reduce the import to new supply ratio between 1978 and 1979, but did not increase the attractiveness of U. S. steel exports abroad. By 1981, the import ratio increased substantially to nearly 15 percent, and the ratio of U. S. steel exports to product shipments dropped further to 3.5 percent. Some domestic producers contend that these recent changes are, in part, the result of unfair trade practices by competing foreign producers. A number of dumping, countervailing duties, and other trade complaints have been filed by the domestic steel industry, of which are still pending. Treatment of these issues, however, is beyond the scope of this study.

Summary

The declining competitiveness of domestic steel may be attributed to a number of interrelated factors. One central factor is that the domestic steel industry has been slower in adopting cost-saving technologies, such as continuous casting, compared with many of its important international competitors. Further, because of relatively low levels of investment in recent years, the typical U. S. steel plant tends to be older, smaller, and less efficient than that of many competing foreign producers.

Another related factor is the more efficient use of materials by many foreign producers compared with domestic producers. Foreign producers, through their adoption of newer technologies, have reduced material costs, including that of energy, despite major price increases over recent years. By comparison, U. S. producers have not achieved comparable efficiencies, largely because of their continued reliance on older plant and equipment.

Still another factor adding to domestic steel industry's comparative disadvantage in the world steel market is the relatively high cost of labor in the U.S. market. A large portion of the cost of producing steel is labor-related, and this cost is determined not only by wage rates, but also by labor productivity. Thus it is significant that data on international steel labor productivity developed by the Bureau of Labor Statistics (BLS) show that during the past two decades labor productivity gains have been greater in Japan than in the U.S. and that West Germany has made sizable productivity improvements relative to U.S. steelmaking in recent years. Such gains have substantially reduced or eliminated the labor productivity advantage long held by U.S. steel producers.

In the future, steel will remain as one of the world's most important engineering materials. However, due to advances in more efficient usage of steel and significant structural change in the economy, steel consumption per dollar of real GNP will likely continue its historical decline. Combined with rapidly expanding foreign capacity, much of which employs the most advanced steelmaking technologies with much lower labor rates, this decline in demand virtually assures further consolidation of the integrated mill sector of the U.S. iron and steel industry. The domestic steel industry's future will depend on its flexibility in adopting these changes, and on its adaptability to the changing world market.

PART II

PRODUCTION TECHNOLOGY
AND
THE EVOLVING ANATOMY OF INPUTS AND INPUT PRICES
SINCE 1958

INTRODUCTION

MAJOR TECHNOLOGICAL CHANGES IN THE INDUSTRY ARE LINKED TO IMPORTANT CHANGES IN INPUT STRUCTURE

The technological innovations discussed in PART I: Section B have contributed to significant changes in both the input structure and in the composition of the inputs used by the U.S. primary iron and steel industry since 1958. For example, they have reduced the demand for blue-collar workers and increased the demand for technically trained personnel, including process control engineers, programmers, laboratory testers, and research and development specialists as well as managers, officials, proprietors and salesworkers. They have also increased the demand for natural gas and electricity in lieu of coal and the demand for scrap metal in place of iron ore, and have led to the substitution of capital for labor, materials and energy. However, despite the long availability of some of these technologies, the U.S. steel industry as a whole has not adopted them at a rate comparable with that in Europe and Japan. Moreover, its approach to introducing new capital-embodied and cost saving innovations has been one of making marginal and incremental modifications to selected, existing facilities rather than through comprehensive investments in new, state-of-the-art plant construction. Indeed, the last "greenfield" facility built in the U.S. was in 1960 by Bethlehem Steel. Ironically, it was already considered obsolete before it was finished.

PART II of this Report examines the evolution of the U.S. primary iron and steel industry's (SIC 331) input structure since 1958. Using data developed by the Capital, Energy and Productivity Studies Division of the Office of Business Analysis, sections A through D of Part II focus on each of the four major input categories -- capital, labor, energy, and materials -- to the production process. Although data limitations cofine much of the analysis to the 1958-80 period, where possible it has been extended to include more recent years.

The discussion contained in these four sections includes an analysis of historical trends in the price and quantity dimensions of each input and of the quality of the industry's capital and labor inputs. Frequently, these trends are compared both across industries and over time in terms of peak-to-peak business cycle periods, so that the influence of business cycles on the various economic measures examined can be controlled.*/

Finally, many of the important inferences "mined" in sections A through D are captured in Section E. The discussion there focuses on important input substitution patterns that occurred in the U.S primary iron and steel industry between 1958 and 1980. Section E also links these substitution patterns to the changes in relative prices paid by the steel industry for its capital, labor, energy, and material inputs and to the basic changes in steelmaking technology that occurred since 1958.

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*/ The years designated as output peaks for each industry discussed in the remainder of this study share two important characteristics: (a) they occur in close proximity to economy-wide periods of stagnant or declining economic growth; (b) they represent years of peak capacity utilization among the years 1958-80; and (c) they are followed by a year in which the industry's output growth declined dramatically. In most cases these "output-growth" peaks were also peaks in the traditional sense -- i.e., they were followed by a recession in the industry. The exceptions include 1959 for both steel and all-manufacturing and 1966 for all- manufacturing. The absolute output peak in all-manufacturing and in steel occurred in 1960, but no absolute peak occurred in all-manufacturing during the mid-sixties.

A. CAPITAL INPUTS

Measures of capital formation are widely considered to be the most important indicators of an industry's technical efficiency or productivity growth potential. This section presents and examines important indicators of capital formation in the U.S. iron and steel industry. Each measure discussed below presents a different view of the industry's capital formation. The presentation progresses from measures of real gross plant and equipment investment, to real net investment, to real net productive investment (net of pollution abatement expenditures), and to real net productive capital stocks of plant and equipment. The quality of these stocks, their utilization rate, and the growth in real capital per worker are also examined.

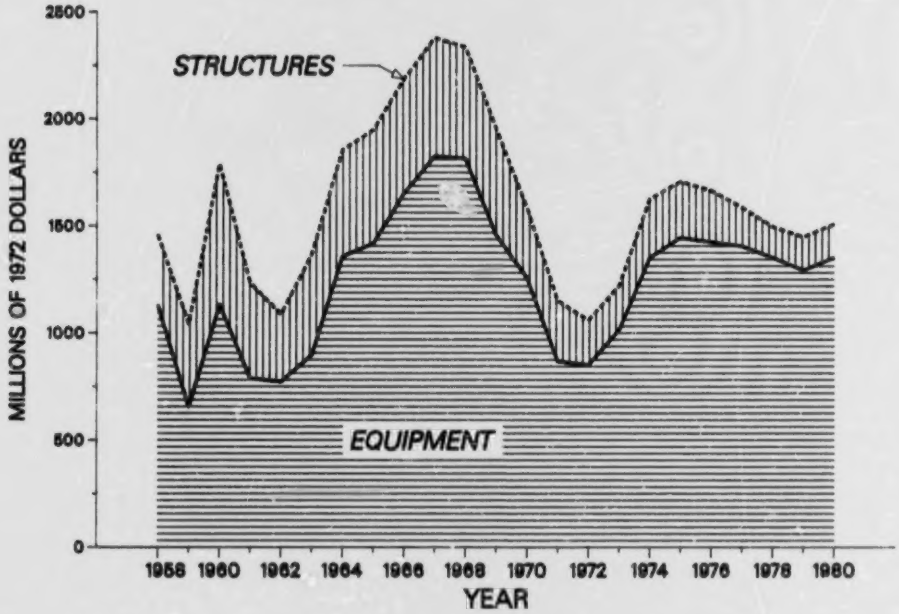
A.1 Capital Investment And Capital Stocks

Real Gross Investment Today Remains At The 1950's Level...

The level of real gross investment (1972 dollars) in structures and equipment by the iron and steel industry (Figure 14) in recent years was little changed from the levels found in the late 1950's.1/ Total gross investment was $1,454 million in 1958, $1,448 in

FIGURE 14

Gross Investment In Plant And Equipment



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

1/ Real gross investment is defined here as total new capital expenditures. Real net investment is defined as the value of real gross investment remaining after accounting for the real value of existing capital lost through discarding and through declines in productive efficiency as the asset ages over time. Real net investment will be negative in years where the real value of this capital lost to production is greater than real gross investment. Similarly, net capital stock is defined as all capital on hand adjusted to exclude assets which have worn out or lost some of their original productiveness.

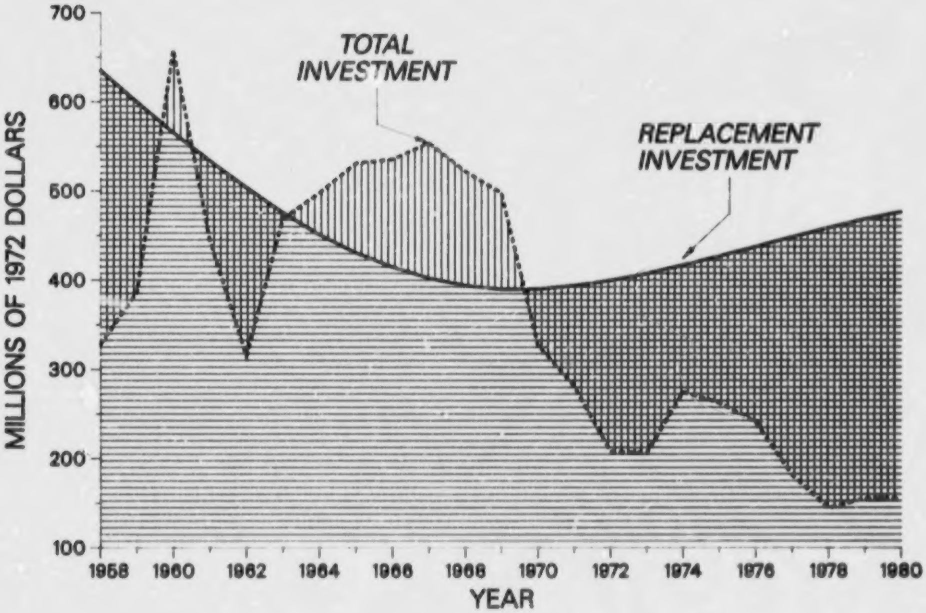
1979, and $1,508 million in 1980. It did increase continuously during the 1962-67 period -- reaching a peak of nearly $2.4 billion in 1967 -- but subsequently fell to a low of $1 billion in 1972, before returning to the trend level of $1.5 billion in 1978. Since 1972 however, the purpose and use of investment funds has shifted away from structures to equipment. Equipment is usually associated with enhancing or maintaining existing plant capacity, whereas investment in structures is usually related to adding to capacity. Figure 14 demonstrates that the large increase in total gross investment spending during the 1960's was due solely to an increase in spending for equipment. Two-thirds of all investment spending in 1959 went to purchase equipment; but, by 1980, equipment spending accounted on average for nearly 90 percent of all capital expenditures.

...But Real Net Investment Has Been Declining Since The Mid Sixties...

A more meaningful statement of capital formation trends in the U.S. iron and steel industry is found in the rate of real net investment in plant and equipment. Gross capital expenditures are largely used for two purposes: first, to replace the value of productive capacity lost through discarding or through the decline of productive efficiency with age and use; and second, to increase capacity. When real gross investment is adjusted for the former, the result is real net investment -- investment which increases capital capacity. When total gross investment exceeds replacement investment, net investment is positive and the capital stock expands. Conversely, when gross investment is lower than the replacement level, the capital stock contracts.

FIGURE 15

Net And Replacement Investment: Structures



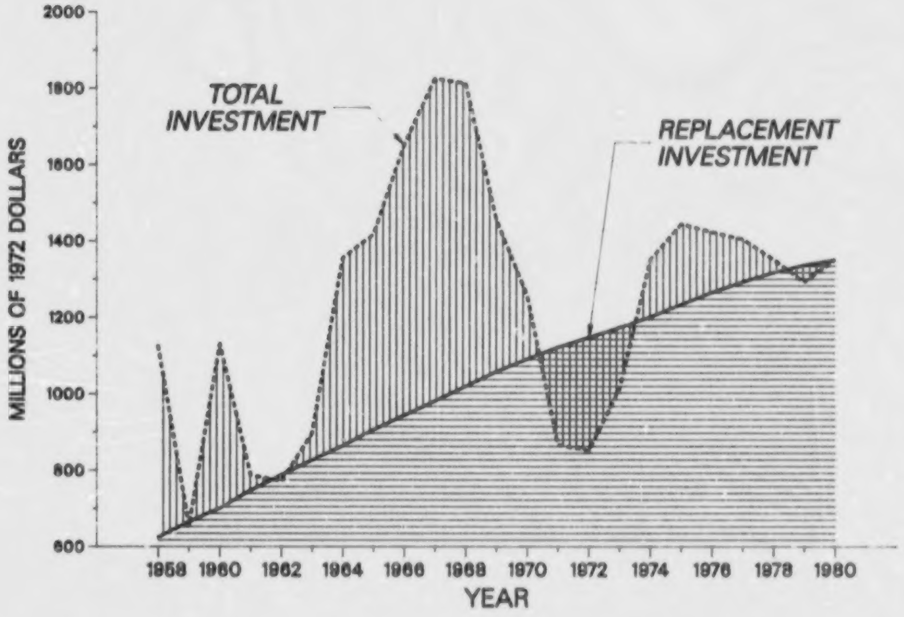
SOURCE: Office of Business Analysis, U.S. Department of Commerce.

Comparing the real replacement investment history in Figures 15 and 16 with that of real gross investment, reveals a strikingly different picture of the state of capital formation in the U.S. iron and steel industry. For example, the only extended period of positive real net investment in structures in the iron and steel industry occurred between 1964 and 1969. In fact, real net investment in structures was negative in 16 of the 23 years between 1958 and 1980 and it has been negative every year since 1969. As a result, the Office of Business Analysis (OBA) estimates that real structures capacity declined nearly $2.3 billion from its peak of $11.2 billion in 1969 to $8.9 billion in 1980 (Figure 17).

The equipment picture is less bleak. Real net equipment investment grew continuously from 1962 through 1967, and was positive through 1970 (see Figure 16). However, after recovering from the 1970-71 recession, the level of real net equipment investment peaked at only $210.5 million in 1975 -- less than one-fourth the $843.7 million achieved at the previous peak in 1967. Moreover, since 1975 the level of real net investment has declined in every year except 1980 (this downward trend continued into 1981 -- real net equipment investment was a negative $17.6 million). As a result, OBA estimates that by 1980 real net equipment stocks declined almost $100 million from the 1970 peak -- from $14.5 billion to $14.4 billion (Figure 18).

FIGURE 16

Net And Replacement Investment: Equipment



SOURCE: Office Of Business Analysis, U.S. Department of Commerce

...And Investment In Productive Capital Is Even Lower.

The growth trends in real capital investment cited above include capital assets acquired for all purposes. An increasing share of capital expenditures in recent years has been devoted to pollution control apparatus. These assets range from devices to remove particulates and polluting gases from smokestack emissions, to water purification and cooling facilities, to solid waste disposal. These assets are usually not employed directly in the production process. Consequently, total capital stock measures may not be useful as an indicator of an industry's productive ability unless assets not used for production are removed.

Most pollution control apparatus purchased by the iron and steel industry is devoted to controlling air pollution. However, 1977 marked a peak period for installation of water pollution control devices when over $200 million was spent. These expenditures coincided with deadlines imposed by the Clean Water Act of 1972, which required installation of secondary wastewater treatment facilities by mid-1977. Thereafter, expenditures for water pollution control facilities fell to less than one-quarter of all pollution control investment in 1981.

Real investment for pollution abatement capital by the iron and steel industry reached a peak level of $346 million in 1976; over 20 percent of capital spending. Plant facilities accounted for $108 million or 31 percent of total pollution abatement expenditures. However, total plant spending for all purposes was only $241 million. Thus, only $133 million was available to replace worn out structures or expand plant capacity.

Size Of Real Net Productive Plant Stock Decreased 28 Percent, 1969-80...

Investment needed to maintain existing levels of plant capacity in 1976 was $438 million. Thus, the real net plant stock shrank by nearly $300 million in 1976. By 1980, the cumulative effect of spending for pollution abatement structures was to further reduce the real net productive stock of structures used for production by almost $1.6 billion (see Figure 17). The combined effect of low levels of plant investment and mandated investment in pollution control structures reduced the real net productive plant stock from a peak of $11.1 billion in 1969 to less than $8 billion in 1980 -- a decrease of nearly 28 percent.

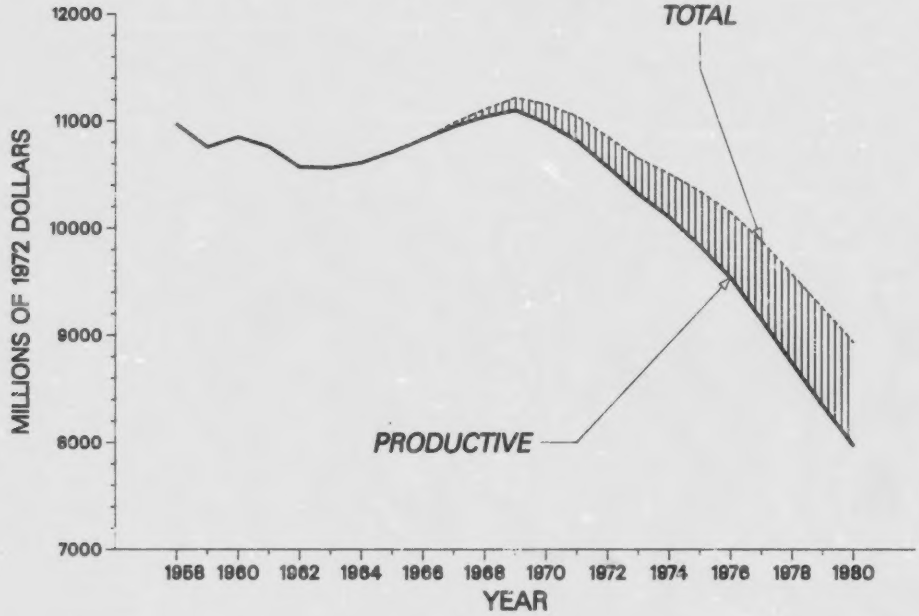
...And Real Net Productive Equipment Stock Decreased 7 Percent, 1970-80.

Capital spending for equipment was also affected by required pollution control expenditures. Figure 18 shows the levels of total and productive equipment stocks in the iron and steel industry. The shaded area represents the stock of control equipment for the years 1967-80. Since 1970, expenditures for pollution control equipment averaged over 14 percent of all real gross equipment expenditures.

During this same period, the real net equipment stock, excluding pollution control equipment, fell $1.0 billion from a 1970 peak of $14.3 billion to $13.1 billion in 1980. This decrease occurred primarily in the 1971-73 period, but trends since 1978 indicate the industry is once again reducing the productive equipment stock.

FIGURE 17

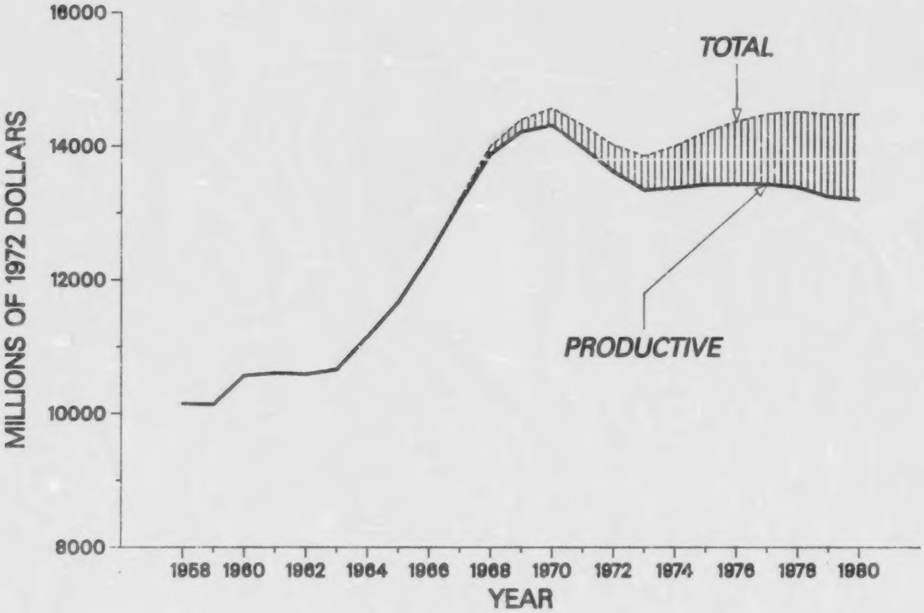
Stocks Of Real Net Plant, 1958-80:
Total, Productive, And Pollution Abatement



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

FIGURE 18

Stock Of Real Net Equipment, 1958-80:
Total, Productive, And Pollution Abatement



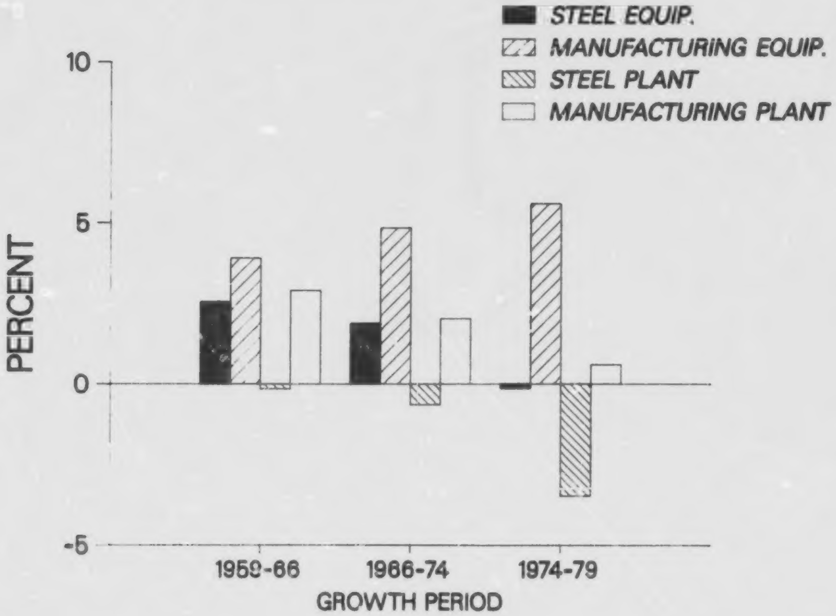
SOURCE: Office of Business Analysis, U.S. Department of Commerce.

Capital Growth Patterns In Iron And Steel Are Out of Synch With All-Manufacturing.

These downward trends in the growth of the iron and steel industry productive capital stock stand in marked contrast to productive capital stock growth in other manufacturing industries. Figure 19 compares the peak-to-peak growth in the productive plant and equipment stocks in iron and steel with the corresponding growth rates in all-manufacturing. During the early, 1959-66 period, the average rate of increase in the iron and steel productive equipment stock was about one percent less than the all-manufacturing rate. However, this gap widened as the iron and steel industry reduced its equipment stock while the rate of increase in the equipment stock in other manufacturing industries was growing at an increasing rate. Iron and steel structures, by contrast, show an average rate of decrease in all three periods whereas the productive stocks of structures in all-manufacturing industries increased in all three periods, albeit at a gradually slower rate.

FIGURE 19

Average Annual Growth In Productive Plant And Equipment Stocks, Over Comparable Peak-To-Peak Intervals Iron And Steel Vs. All-Manufacturing



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

A.2 Capital Quality

The Size Of The Capital Stock Is Only Part Of The Story: Aging Of The Capital Stock.

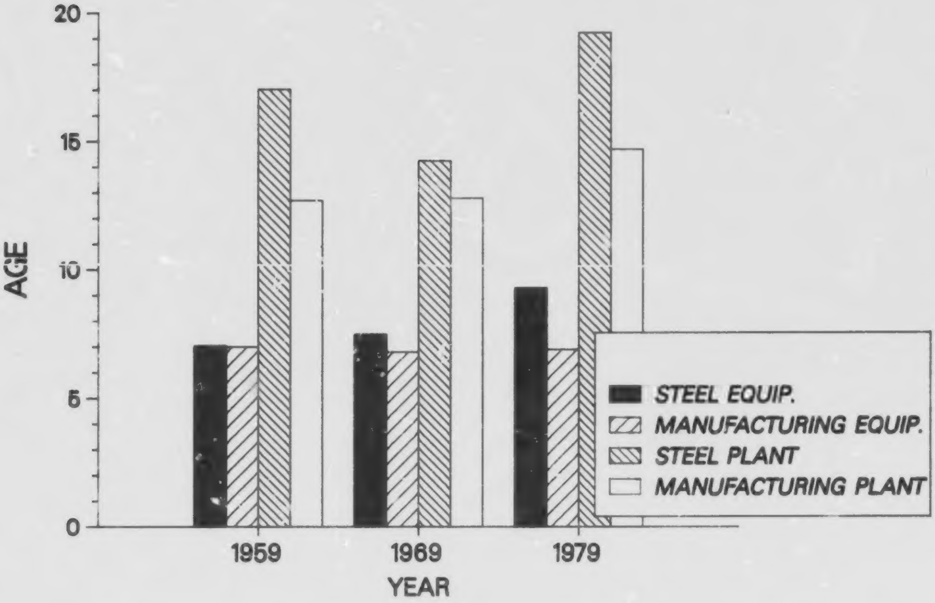
The size of the productive stock of iron and steelmaking capital is an important measure of industrial capacity. However, the condition of that stock is also an important indicator. Just as a more educated work force is more productive, a newer, more technologically advanced capital stock is more productive. The years immediately following World War II show the nation's iron and steelmaking facilities in dismal condition. In 1950, over 60 percent of gross iron and steelmaking structures in use had been constructed before 1930 and the average age of the gross equipment stock was nearly ten years. By contrast, the all-manufacturing gross equipment stock was three years newer and the gross plant stock averaged six years newer.

Investment Growth Spurt In 1964-69 Improves Quality Of Capital Stock Temporarily...

Growth in capital expenditures during the early 1950's and again from 1964-69 decreased the average age of iron and steelmaking structures by 30 percent, to 14 years. The equipment stock followed a somewhat similar pattern with the average age falling to 6.7 years by 1958. One would have expected an equally dramatic drop in the age of the equipment stock following the 1964-69 growth period.

FIGURE 20

The Average Age Of The Gross Productive Capital Stock,
At Selected Output Peaks
Iron And Steel Vs. All Manufacturing



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

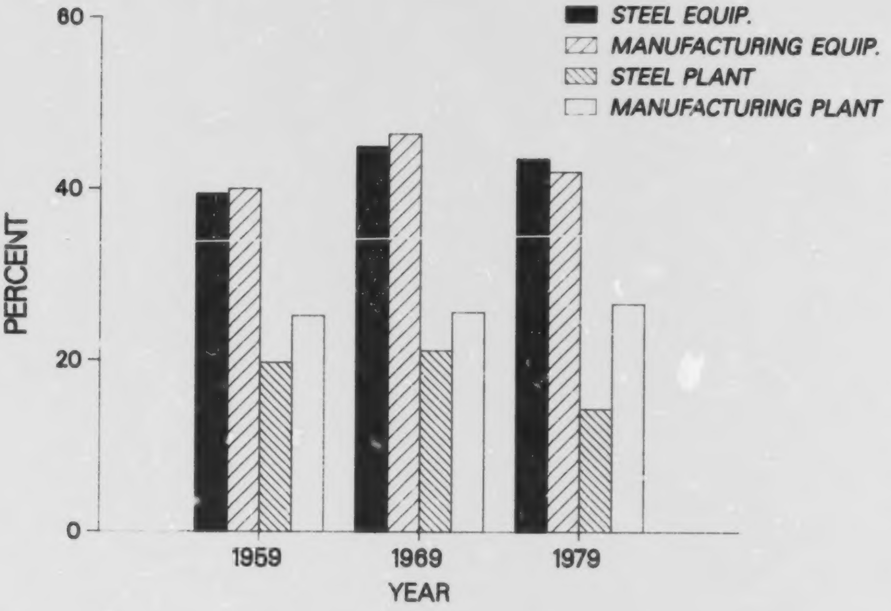
However, the strong shift in investment patterns towards equipment spending created an equally strong shift in replacement needs. Consequently, the productive equipment stock aged to 7.4 years by 1969. These two growth spurts did narrow the gap between iron and steel and other manufacturing industries (see Figure 20). By 1969, iron and steel plant averaged only 1.5 and equipment .5 years older than in manufacturing industry facilities overall.

...As Quality Of Capital Declines Steadily After 1969.

Beginning in 1970, the average age of both the plant and equipment stock began to increase. This deterioration in the quality of the capital stock coincided with the lower rate of capital formation during the 1970-80 period and the increased emphasis on spending for pollution abatement capital. By 1980, the average age of the plant stock had increased 4.5 years to nearly 19 years. In addition, the percent of productive plant assets considered new (less than five years old) and more technologically advanced plummeted to less than five percent of the plant stock -- lower than any year since 1949 (see Figure 21). Over 80 percent of the productive plant stock had been in use for over ten years and 40 percent was purchased before 1960. The productive equipment stock also aged by over one year, rising from an average of 7.4 years at the end of 1969 to 8.7 years in 1980. New equipment accounted for 43 percent of the equipment stock in 1969. By 1980, new equipment had fallen by 11 percentage points to less than one-third of the equipment stock. By contrast, the portion of the total manufacturing productive plant and equipment stock that was new showed only a modest decrease between 1970 and 1980.

FIGURE 21

Percent Of Productive Capital Stock Less Than Five Years Old:
At Selected Output Peaks
Iron And Steel Vs. All Manufacturing



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

A.3 Capital Per Worker

Capital Per Worker Increases....

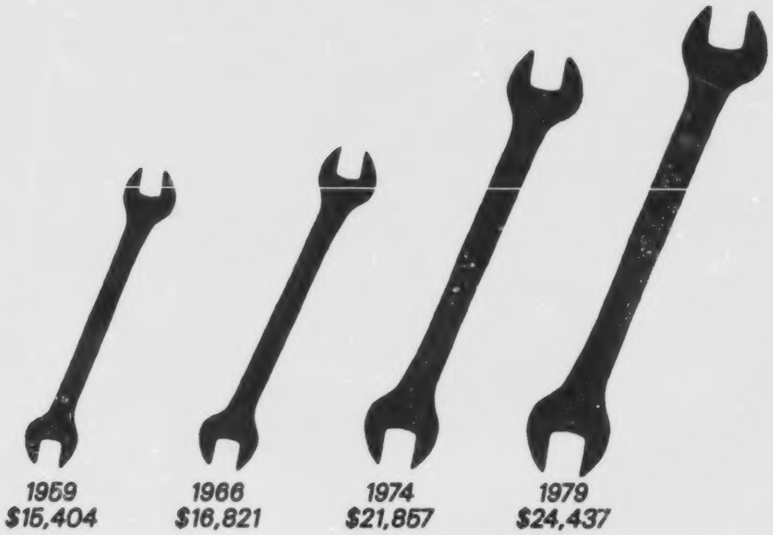
The real net capital stock per worker (excluding pollution abatement capital) in the iron and steel industry increased by over $10,000 between 1958 and 1980, from $36,500 per worker to $47,800 (1972 dollars). Moreover, with the exception of two brief periods in 1959-60 and 1972-74, capital per worker increased every year during this period. These figures include all workers in the industry -- both production and nonproduction workers. However, the great majority of iron and steel capital is used for production purposes. When nonproduction workers are excluded from the calculation, a more dramatic shift in capital per worker becomes apparent. Real productive capital per production worker increased by $17,000, from $45,000 to $62,000 (1972 dollars). Figure 22 illustrates the relative change in the level of real capital per production worker in peak output years 1959, 1966, 1974, and 1979.

...But, This Is Not Due To Growth In Capital Stock.

Capital per worker is often used as a measure of the change in the capital intensiveness of an industry. One might infer from the growth of capital per worker in the iron and steel industry that its capital stock was growing faster than its employment. This, however, is not the case. Recall that there was virtually no capital stock growth in iron and steel between 1958 and 1980. Thus, its capital per worker growth during this period was because the industry reduced its employment of production workers at a faster rate than it reduced its capital stock.

FIGURE 22

Real Productive Capital Per Production Worker
(1972 Dollars)



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

The dynamics of the increase in steel's capital:labor ratio stand in marked contrast to those behind the increase in capital per worker in manufacturing industries overall. Real productive capital stock per production worker in all-manufacturing increased by over $10,000 (1972 dollars) between 1958 and 1980, from $16,000 to $26,400 per worker. However, strong growth in both total manufacturing employment and net capital stock during this period indicates that the 62.5 percent increase in its capital:labor ratio is being driven by a healthy, growth-oriented dynamic, compared with the declining-industry dynamic driving the growth in the steel industry's capital:labor ratio. The number of production workers in all manufacturing industries grew by 20 percent between 1958 and 1980, from 11.6 million workers to nearly 14 million. The real net productive capital stock nearly doubled during this same period, rising from $185.6 billion to $367.2 billion (1972 dollars).

A.4 Capital Utilization

The rate of capital utilization is one indicator of how well the iron and steel industry can meet the demand for its products. It also serves as an indicator of when expansion of productive capacity is necessary to satisfy increased demand. To investigate these issues, Figure 23 compares a new measure of capacity utilization developed by OBA with the measures developed by the Federal Reserve Board and Wharton EFA.2/ Unlike the FRB and Wharton Series, the OBA capacity utilization rates are explicitly based on the iron and steel industry's available net capital stock of plant and equipment, after the removal of capital whose primary purpose is pollution control.3/ In general,

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2/ As a practical matter, an industry's output capacity is determined by its stock of fixed plant and equipment. Accordingly, common usage treats the concepts of capital utilization and capacity utilization as essentially equivalent notions. Moreover, it can be demonstrated that the OBA capacity utilization rate (discussed in the text and footnote 3 below) is formally equivalent to a capital utilization rate.

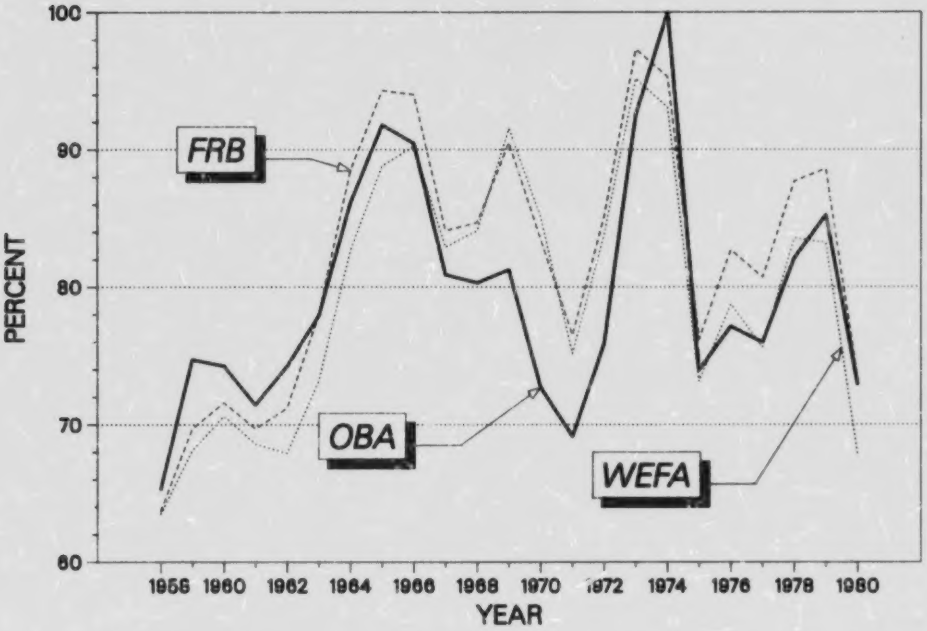
3/ There are three types of capital utilization rate measures: survey-based, production based, and production/capital stock-based. Examples of the first type include the utilization rates published by McGraw-Hill and by the Bureaus of Economic Analysis and the Census; and, to some extent, the series published by the Federal Reserve Board. The Wharton series is an example of the second type, and the OBA series of the third type. Concerning survey-based measures, Frank DeLeeuw of BEA noted that, compared with either production-based or production/capital stock-based utilization rates: "Survey-based measures of utilization displayed a cyclical sluggishness that has been disappointing and puzzling ... survey-based utilization rates imply an implausible degree of short-run sensitivity of capacity to the rate of growth of output." DeLeeuw analyzed several reasons for this phenomenon and concluded that overreporting of "no change" and the use of labor rather than output to measure capacity utilization by a large percentage of respondents explained "a substantial fraction of the differences in amplitude of swing between survey-based and production-based measures of capacity utilization".

In comparing production-based and production/capital stock-based measures, the former type may miss slowdowns or speedups in capacity growth due to fluctuations and trends in investment. As a result, such measures are likely to fall more in contractions and rise more in expansions than capital stock-based measures and their levels may be above or below capital-based measures for extended periods of time. Until recently, the FRB combined OBA's capital stock data with McGraw-Hill's capacity growth survey data to smooth its initial survey-based estimates of industrial capacity and capacity utilization in order to eliminate both types of bias. However, since its recently revised data, shown in Figure 15, did not incorporate capital stock data, it is probable that some of the difference between the FRB and OBA series are attributable to these biases.

each series, though constructed differently, shows a falling off in capacity utilization after 1974 to an average rate of about 70 percent utilization in 1980. More recent data show continued declines in the rate of capacity utilization to levels of about 50 percent in 1982.

FIGURE 23

Capacity Utilization Rates:
Office of Business Analysis (OBA), Federal Reserve Board (FRB),
And Wharton (WEFA)



SOURCE: U.S. Department of Commerce; Wharton Econometric Forecasting Associates; Board of Governors of the Federal Reserve System.

Uninterrupted Increases In Utilization Rate, 1961-65...

During the 1958-61 period, the U.S. primary iron and steel industry experienced persistently low rates of utilization. The low rate of capacity utilization in 1958 was caused by a relative steep recession in 1957 and 1958. This period was followed by a 119-day steel strike in 1959 and an economy-wide recession in 1960. Between 1961 and 1965, however, the industry experienced a period of sustained growth, during which its utilization rate grew steadily from a low of 71.4 percent in 1961 to a peak of 91.8 percent in 1965.

...But Cyclical Instability Dominates, 1966-80...

All three capacity utilization series show the iron and steel industry operating at or near full capacity in 1965-66 and 1973-74. The years between these output peaks, however, are dominated by a succession of business cycles which caused large swings of 10 percentage points or more in the industry's utilization rate. The capital stock-based OBA series show that the industry's utilization rate fell nearly 20 percentage points from its 1965-66 operating rate, to a low of 72.7 percent of capacity in 1971.

...And The Industry Experiences Chronic Excess Capacity After 1974.

Figure 23 shows that after 1974, unlike after all previous post-1958 recessions, the industry consistently operated at low rates of capacity utilization; even though both output and the capital stock were shrinking during this period. The 77.9 percent average rate of utilization during 1975-80 compares with an 83.5 percent average rate during 1965-74. The period 1975-80 thus marked the first phase of what is now more than 10 years of chronically low operating rates in the steel industry. With an 80 percent utilization required to break even, the industry has been forced between 1974 and 1984 to close some 200 facilities, idle more than 20 plants or parts of plants, and reduce its steelmaking capacity from 155 million to 135 million tons. Despite this, the industry continued to experience sizable losses in 1984, leading most observers to forecast further large-scale reductions by 1990.

Productivity Growth Patterns Mirror Growth Patterns In Capacity Utilization Rate.

Changes in the rate of labor productivity closely follow changes in the rate of capital utilization. When iron and steel mills are operating at below normal levels of utilization, capital and labor resources are idle, indicating a lower rate of labor productivity. However, as demand for steel mill products increases and the utilization rate increases, labor productivity goes up. The faster the rate of change in the utilization rate, the faster the change in the rate of labor productivity increase. Table 6 shows changes in OBA's capacity utilization rates and labor productivity growth during three major periods of expansion and two periods of contraction.

The 1971-74 and 1974-75 periods show that the greatest change in labor productivity accompanies a rapid rate of change in capital utilization. Slower rates of change show a corresponding slowdown in the rate of productivity growth.

TABLE 6

Average Rates Of Growth In Capacity Utilization
And Labor Productivity

Period	Capacity Utilization	Labor Productivity
Trough-to-Peak:		
1958-66	4.4%	4.2%
1971-74	13.3	7.5
1975-79	3.7	2.1
Peak-to-Trough:		
1966-71	-5.1	-1.1
1974-75	-26.0	-16.1

SOURCE: Office of Business Analysis, U.S. Department of Commerce.

Summary

The primary iron and steel industry is undergoing a major transition in its capital stock. Demand for iron and steel products has fallen dramatically from previous years, resulting in large amounts of excess capacity. The industry has reacted to the changing market condition by shedding capital -- not replacing capital as it wears out -- and by shutting down older, less efficient mills. While these actions have reduced the industry's capital stock to enable greater utilization of remaining production facilities, the condition of the capital stock and the persistently low rates of utilization since 1974 indicate more adjustments will be forthcoming. Much of the iron and steel plant in use today was constructed before 1960. New, more productive technology has passed many of these facilities by, making it difficult to compete with more efficient foreign and domestic producers. However, recent newspaper and business journal accounts indicate that iron and steel producers generally and electric-arc companies in particular are planning major investments in newer technologies, such as continuous casting machines. But, not all mills will be retro-fitted and continued closing of numbers of existing mills is certain. In 1983 and early 1984, for instance, steel companies announced closings of many major plants, estimated by AISI to have reduced national raw steel capacity by 10% -- the largest decline on record.

B. RATES OF RETURN AND COSTS OF CAPITAL

Underlying the deterioration in the steel industry's stock of productive physical capital since the late sixties was a pronounced deterioration in its financial health. Sections B.1-B.3 examine the history of several important financial health indicators, including rates of return, costs of capital, interest and debt burden, net cash flow, and sources and uses of funds in the overall steel industry. Section B.4 examines the relative financial health of two important segments of the overall steel industry--the mini-mill segment and the integrated-mill segment.

B.1 Rates Of Return

Except For 1973-74, The Rate Of Return On Capital Has Been In Systematic Decline Since 1966...

The after-tax rate of return on capital in the overall primary iron and steel industry steadily deteriorated after 1966 and, with the exception of 1974, the long-run trend over successive peak-to-peak business cycles has been downward (Figure 24). [1] Table 7, for example, shows that the industry's average annual after-tax rate of return

TABLE 7

Comparison Of Average Annual After-Tax Nominal Rates Of Return, During Selected Peak-To-Peak Business Cycles[a]

	1959-66	1966-74	1974-79	1979-83
Primary Iron and Steel	4.2%	3.5%	4.0%	-0.3%
All-Manufacturing [b]	7.7	7.3	8.8	8.4%

[a] 1983 is not a peak-output year but it is the last year for which data were available.

[b] The data shown for manufacturing are for the comparable peak-to-peak intervals: 1959-66, 1966-73, 1973-79 and 1979-83.

SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, Inc.

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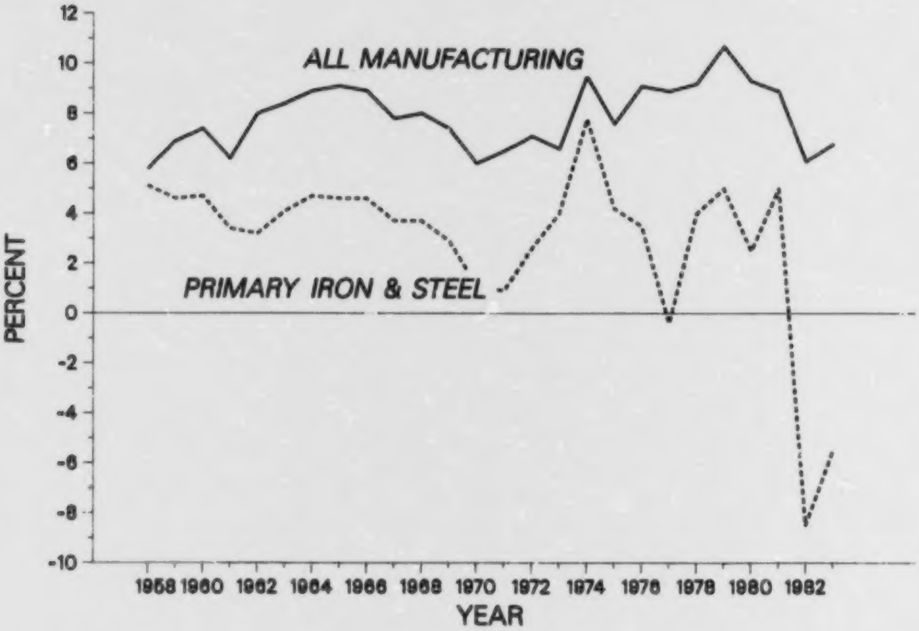
[1] The rate of return and other financial statistics reported in this section are based on a sample of 57 companies, including 13 "mini-mill" companies, taken from Standard and Poor's Compustat. The Office of Business Analysis adjusted Compustat's consolidated company-level profit and capital stocks data to an industry-level basis prior to computing the rate of return on capital. This adjustment was performed in two steps: (1) any company with less that 20 percent of its shipments in the steel industry was eliminated using data constructed by Control Data Corporation; and (2) the shares of consolidated company profits and capital stocks belonging just to steel were estimated using business segment data from Compustat for the years 1976-80; and by using the average annual change over the 1976-80 period to extrapolate the steel shares of company-wide profits and capital stock backwards to 1958.

decreased from 4.2 percent during the 1959-66 cycle to 3.5 percent during the 1966-74 interval; increased to 4.0 percent during the 1974-79 cycle; and then **fell by 4.3 percentage points to minus 0.3 percent during the 1979-83 interval.**

FIGURE 24

Ratio Of Operating Profits Before Extraordinary Items And Discontinued Operations To Book Value Of Capital Stock



SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, Inc.

...The Gap With The All-Manufacturing Rate Of Return Continued To Widen And Averaged Less Than One-Half The All-Manufacturing Rate, 1958-83.

The return on capital in the overall steel industry has been consistently lower than that in all-manufacturing (Figure 24). Even in its best year, 1974, the industry's 7.9 percent rate of return was considerably lower than the 9.5 percent earned by manufacturing industries overall. And, during 1982, the steel industry's worst post-1958 year, its rate of minus 8.5 percent was 14.6 percentage points lower than the all-manufacturing rate of 6.1 percent.

Table 7 demonstrates the widening difference between the return on capital in the steel industry and the return in all-manufacturing. For example, the gap widened from 3.5 percentage points during the 1959-66 interval, to 4.8 percentage points during the 1974-79 interval, and to 8.7 percentage points during the 1979-83 interval. Moreover, since 1966 the peak-to-peak average annual rate of return in steel has consistently been less than half that earned by manufacturing industries overall.

With Interest Expenses Outpacing Profits, The Industry's Interest Burden Grew...

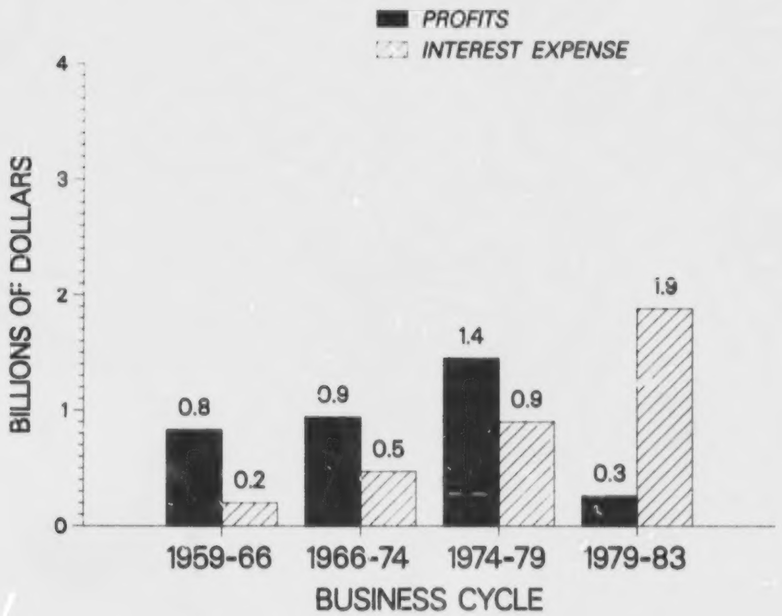
Between the 1959-66 and 1966-74 business cycles, average annual profits in the steel industry increased by $0.1 billion, or approximately 13 percent; the industry's average annual interest expenses, however, rose by almost $0.3 billion, or about 135 percent (Figure 25). As a result, the industry's interest burden increased from 19 cents per dollar of capital income in the 1959-66 cycle to over 33 cents per dollar of capital income during the 1966-74 cycle. 2/ During the 1974-79 cycle, average annual interest expense increased by $0.43 billion to $0.90 billion, but average annual profits rose by $0.51 billion to $1.45 billion during the same period. These two offsetting factors combined to effect an increase of only 5 cents per dollar in the industry's interest burden between the 1966-74 and 1974-79 cycles.

Since the interval from 1979 to 1983 is not a peak-to-peak business cycle, a valid comparison cannot be made between average annual parameters for this interval and those of preceding cycles. The data for the 1979-83 period are, nevertheless, indicative of the increased deterioration which occurred in the steel industry since 1979. Average annual profits, during the 1979-83 interval, plunged by $1.21 billion to only $0.26 billion,

FIGURE 25

Average Annual Levels Of Profits And Interest Expense, Over Selected Peak-To-Peak Business Cycles

Average Annual Level
($ Billions)



SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, Inc.

2/ Interest burden = interest expense ÷ (after-tax income and interest expense).

while average annual interest expenses grew by almost $1 billion to $1.88 billion. **Thus, on average, eighty-eight cents out of each capital income dollar earned by the overall steel industry during this period was consumed by interest expense.**

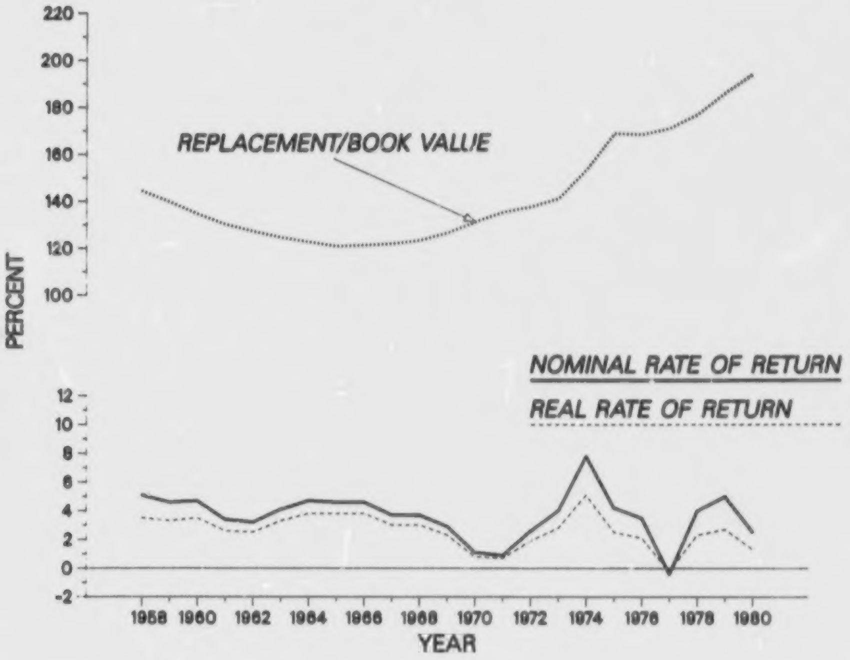
...And As The Replacement Cost Of Assets Rose, The Real Return On Capital Fell...

Figure 26 shows that, during the period from 1958 to 1966, the steel industry's real rate of return on capital increased from 3.5 percent in 1958 to 3.8 percent in 1966. This net gain was the result of a decrease of 16 percent in the replacement costs of assets combined with a decrease in the nominal rate of return of 0.5 percentage points -- from 5.1 percent in 1958 to 4.6 percent in 1966.

Since 1966, however, the real rate of return decreased by 2.5 percentage points -- from 3.8 percent in 1966 to just 1.3 percent in 1980. This loss was the result of a steady increase in the replacement cost of assets from an index of 121.2 in 1966 to 194.0 in 1980 -- an increase of almost 60 percent--plus a decrease in the nominal rate of return of 2.1 percentage points--from 4.6 percent in 1966 to 2.5 percent in 1980.

FIGURE 26

Replacement Cost Of Assets, Nominal Rate Of Return On Capital, And Real Rate Of Return On Capital



SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, Inc.

Table 8 shows the decrease in the average annual real return on capital over selected post-1958 business cycles. The average rate decreased from 3.3 percent during the 1959-66 cycle to 2.4 percent during the 1974-79 cycle. The much smaller, 0.2 percentage points decrease in the average annual nominal rate of return over the same period reflects the effect of inflation on the cost of replacing the industry's existing stocks of plant and equipment. Table 8 indicates that inflation destroyed 25.7 percent of the capital-asset purchasing power of profits earned during the 1966-74 cycle but destroyed nearly 40 percent of the purchasing power of profits earned during the 1974-79 cycle.

TABLE 8

Comparison Of Average Annual Nominal And Real Rates Of Return, During Selected Peak-to-Peak Business Cycles

	Business Cycle		
	1959-66	1966-74	1974-79
Nominal Rate of Return	4.2%	3.5%	4.0%
Real Rate of Return	3.3	2.6	2.4

SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, Inc.

....And Operations Provided Less Cash To Liquid Resources...

A clearer picture of the declining solvency of the overall primary iron and steel industry can be obtained by observing the behavior of the cash flow provided by its operations. Figure 27 contrasts the working capital and the cash flow provided by operations over the period 1971-80. Cash flow provided by operations is derived by netting yearly changes in the current assets and current liabilities accounts from working capital provided by operations.[3]

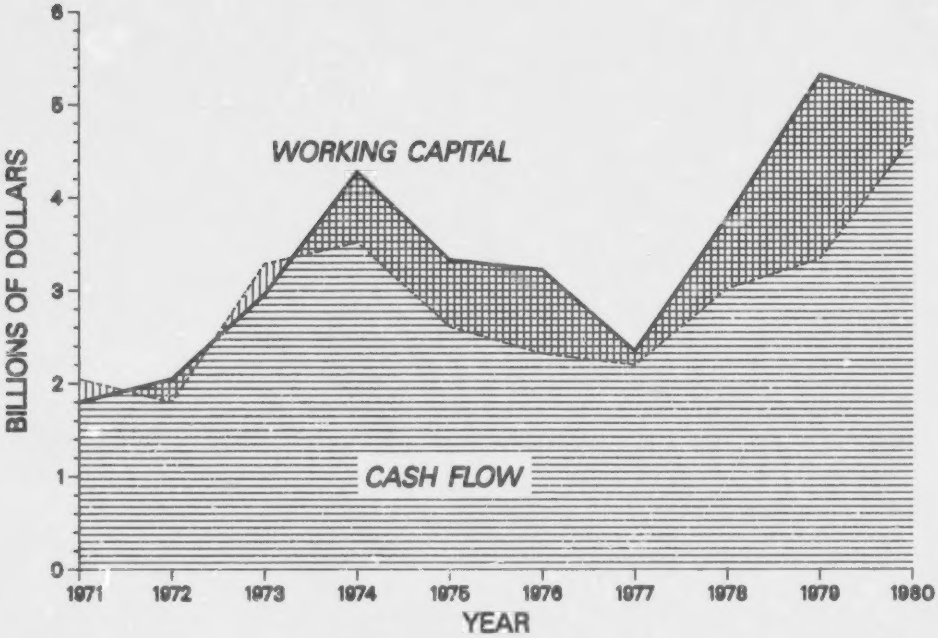
From 1971 to 1973, operations were a relatively efficient supplier of cash; indeed the net cash flow provided by operations was greater than the corresponding value of net working capital provided by operations in 1971 and 1973 but somewhat smaller in 1972. Ironically, in 1974, when the industry's rate of return on capital was at its post-1958 maximum, a significant portion of funds generated from operations was not translated into cash flow. And, with the exception of 1976, this condition persisted over the entire 1974-80 period. This fact is demonstrated by the crosshatched area in Figure 27, which represents the differential between net working capital and cash flow provided by operations.

---

[3] To derive cash flow provided by operations, one starts with working capital provided by operations from the statement of changes in financial position, adds changes in current asset accounts (other than cash) that decreased and current liability accounts that increased, and subtracts changes in current asset accounts (other than cash) that increased and current liability accounts that decreased. In accounting terms, this is equivalent to adding credit changes and subtracting debit changes in the working capital accounts.

FIGURE 27

Working Capital And Cash Flow Provided By Operations



SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, Inc.

B.2 Sources And Uses Of Funds

...Leading To A Growing Reliance On External Funds And Debt Financing...

With internal funds unable to provide adequate financial capital, the industry turned to external sources. Figure 28 shows the chronic deterioration and increasing instability of the steel industry's operating income as a source of funds. The share of funds obtained from operations dropped sharply from 81 percent at its peak in 1974 to just 44 percent by 1977. Even with a recovery during 1977-79, operations were able to generate only 62 percent of total funds. The impact of the industry-wide recession of 1981-82 is dramatically shown in Figure 28 -- the share of funds provided from operations dropped from 53.7 percent in 1981 to only 6.2 percent in 1982 and then increased slightly to 12.6 percent in 1983.

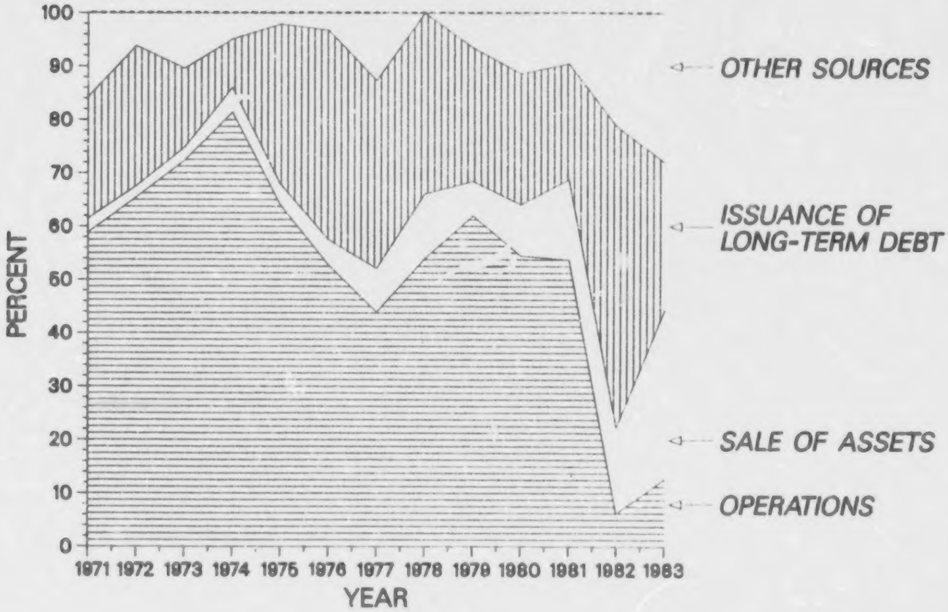
In contrast, the overall manufacturing sector enjoyed both a much larger and more stable base of internal funds to finance growth. Funds from operations ranged only from a minimum of 64 percent to a maximum of 74 percent of total funds during the 1971-80 period. Furthermore, the share of funds provided by operations between 1981 and 1983 in all-manufacturing decreased only from 62.9 percent in 1981 to 59.4 percent in 1982 and then rose to 62.6 percent in 1983.

Figure 28 demonstrates another important characteristic of the steel industry -- its increasing use of external funds, mostly in the form of long term debt. Long-term debt provided an average of 28 percent of the industry's total funds during the 1971-83

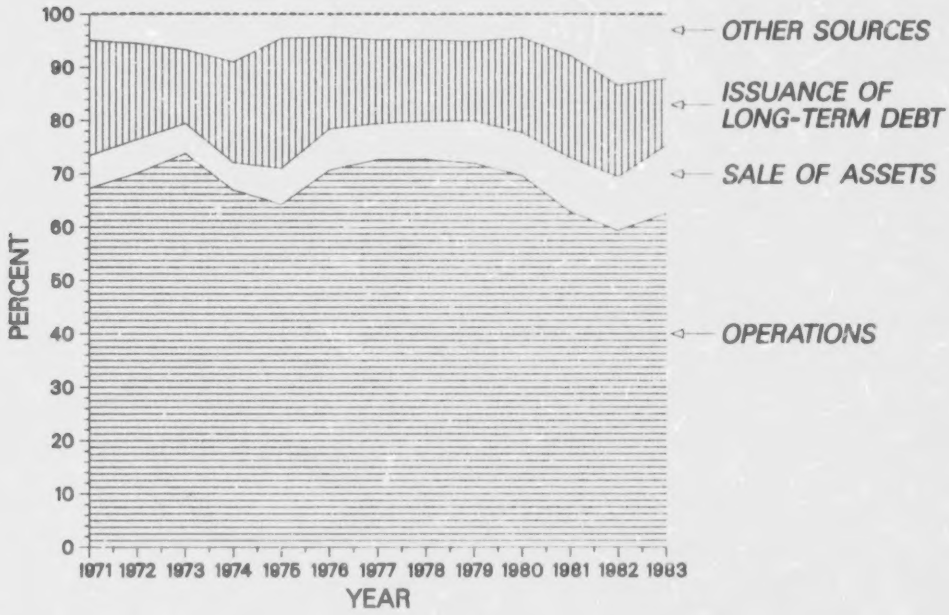
FIGURE 28

Percentage Distribution Of Sources Of Funds

Primary Iron And Steel



All Manufacturing



SOURCE: Office of Business Analysis, U.S Department of Commerce and Standard & Poor's Compustat Services, Inc.

period, **reaching a high of over 56 percent in 1982.** In comparison, long-term debt averaged only 17.4 percent of total funds in manufacturing industries overall during this period, with a maximum of 24 percent in 1975. Equally disturbing in Figure 28 are the large fluctuations in the magnitude of steel's sources of funds. These gyrations indicate instability to the capital markets and cause increased risk premiums to be placed on the industry's use of both equity and debt financing.

...To Finance New Capital And To Service The Debt.

Thus, as the use of long-term debt continued to increase and funds from operating income continued to decrease, a vicious cycle was created. Originally driven to use debt financing as the source of funds for capital improvements and expansion, the steel industry eventually found itself in a situation where it had to rely on new debt funds to repay the interest and premiums associated with old debt rather than to improve the capital stock -- a sort of "catch 22".

Figure 29 compares the uses made of funds by the total steel industry and by manufacturing industries overall. The noteworthy items are: (1) the disproportionately low percentage used by the steel industry for cash dividends and capital expenditures; (2) the much higher use of funds by the steel industry for amortizing long-term debt relative to the overall manufacturing sector; and (3) the successively diminishing share of funds which the steel industry used for capital expansion in each year from 1975 through 1983.

Table 9 summarizes the disparity between steel and all-manufacturing in the use of funds between 1971 and 1983. For example, the steel industry used, on an average, less than 11 percent of its funds for cash dividends, while all manufacturing used 15.8 percent. Furthermore, steel used almost 21 percent of its funds to amortize long-term debt, while all-manufacturing used only 12 percent for this purpose. Thus, capital expenditures and cash dividends continued to decrease, and more borrowed funds were necessary to amortize the existing debt and repay the interest.

TABLE 9

Average Annual Use Of Funds, During 1971-83

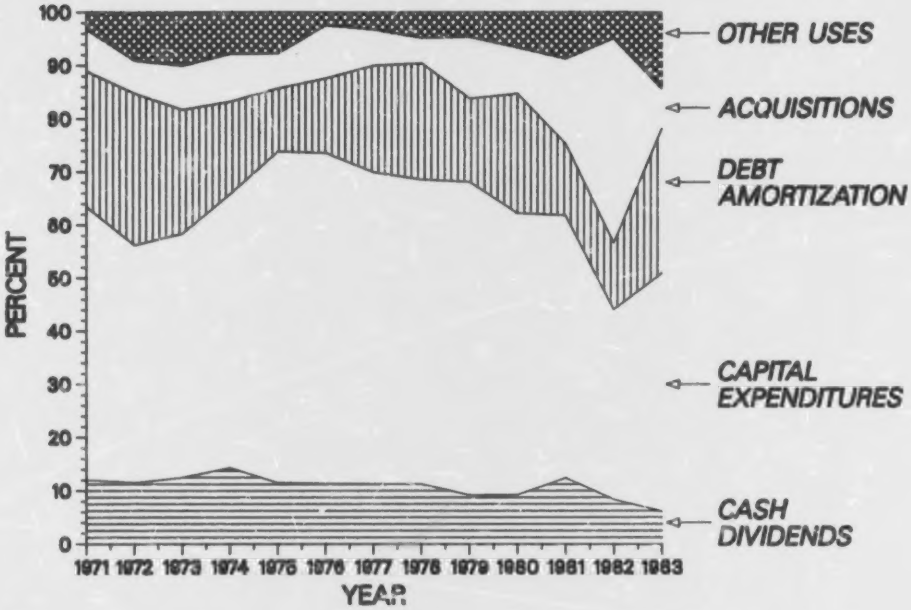
	Primary Iron and Steel	All-Manufacturing
Cash Dividends	10.8%	15.8%
Capital Expenditures	52.0	56.3
Increase Investments	3.3	3.6
Amortize Long Term Debt	20.7	12.1
Purchase of Stocks	1.2	1.7
Acquisitions	6.4	5.5
Other	5.6	5.0

SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, Inc.

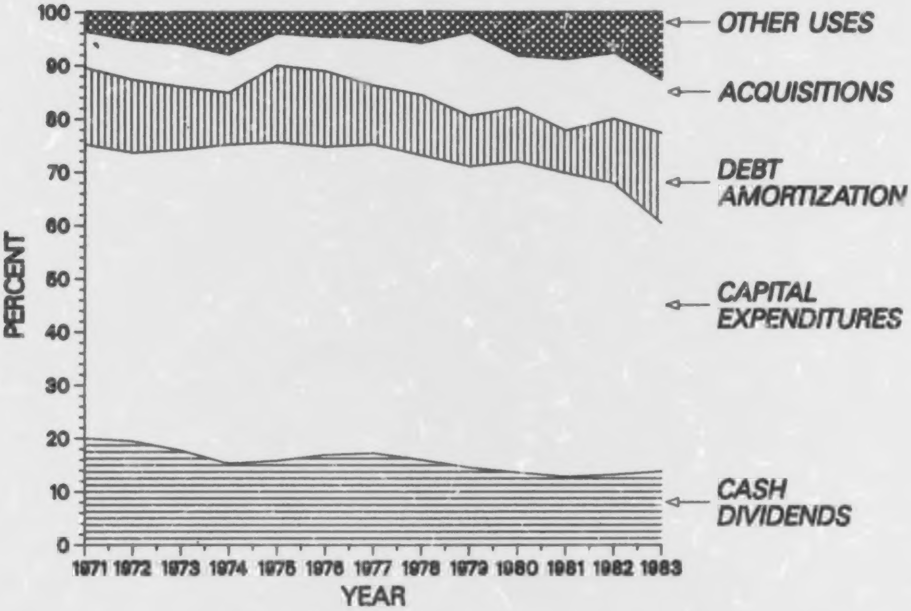
FIGURE 29

Percent Distribution Of Uses Of Funds

Primary Iron And Steel



All Manufacturing



SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, Inc.

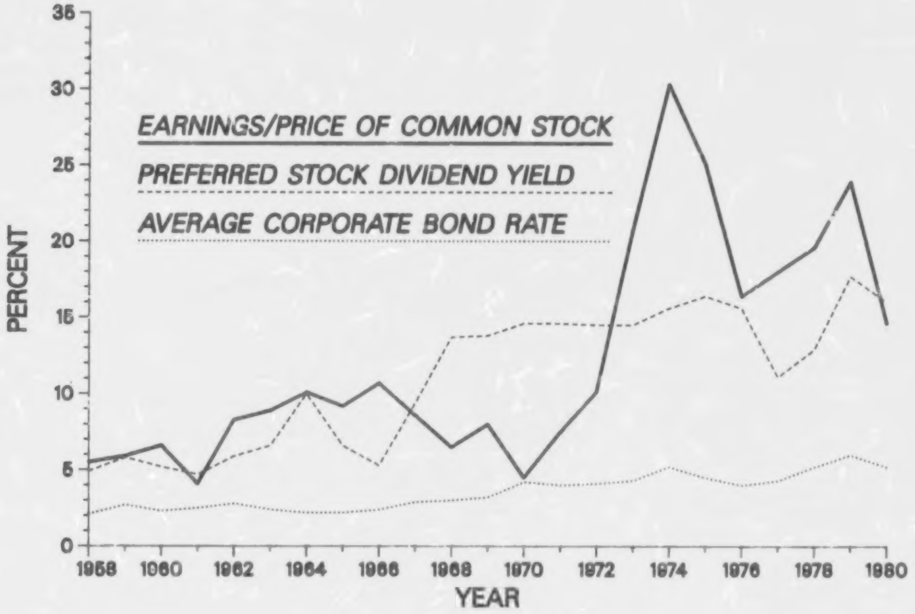
B.3 Costs Of Capital

As A Result, Steel's After-Tax Cost Of Capital Escalated Rapidly After 1966...

As could be expected, new financial capital has become an increasingly expensive commodity for the U.S. iron and steel Industry. The financial markets reacted to the progressive deterioration of the industry's financial health by placing a large and growing premium on further infusions of capital. This process took the form of price decreases in the industry's common stock together with increases in the cost of common equity (the earnings/price ratio) and in the coupon rates on its preferred stock and long-term debt. Figure 30 demonstrates the growing after-tax cost of equity and debt capital to the steel industry.

FIGURE 30

Average Annual After-Tax Costs Of Equity And Debt Capital, 1958-80



SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, Inc.

The cost of common equity (the earnings:price ratio) to the U.S.primary iron and steel industry nearly doubled during the 1959-66 peak-to-peak interval, rising from 6.0 percent in 1959 to 10.7 percent in 1966. This increase was the result of a drop in the industry's average price per share from $77.90 in 1959 to $34.60 in 1966. The average cost of common over the whole 1959-66 period was 8.0 percent.

During the 1966-74 peak-to-peak interval, however, the average cost of common rose nearly 4 percentage points to 11.9 percent. The average price per share increased by $3 between 1966 and 1968 and the industry's earnings:price ratio decreased by 4.2 percentage points. But, while the average price per share decreased by more than $12 between 1968 and 1970, the earnings:price ratio also declined from 6.5 percent in 1968 to 4.5 percent in 1970, because of a large cyclical decrease in earnings. During the 1970-74 period, the market's increasing wariness of the steel industry was manifested in a 26.5 percentage points increase in the industry's cost of common equity--from 4.5 percent in 1970 to 31 percent in 1974, despite the fact that earnings per share increased from $1.10 in 1970 to $7.50 in 1974.

By the 1974-79 interval, the industry's average cost of common equity grew to over 21 percent--nearly double the 1966-74 average cost and almost triple the 1959-66 average cost. From 1974 to 1976, the average price per share of steel industry common staged a brief price rally, rising from $24.40 in 1974 to $33.60 in 1976. However, this rally was followed by large stock price decline between 1976 and 1979, with the average price per share falling to its minimum value of $14.70 in 1979. Meanwhile, earnings per share decreased from a peak of $7.50 in 1974 to $3.50 in 1979. The combined effect of these earnings and price movements was a reduction of approximately 7 percentage points in the cost of common equity between 1974 and 1979.

With the exception of 1964, the cost of preferred equity (the dividend yield) remained less than 7 percent during the 1958-66 period (Figure 30). Thereafter, the dividend yield increased rapidly from 5.3 percent in 1966 to 13.7 percent in 1968. From 1968 to 1975, it grew at a much slower rate, to a high of 16.4 percent in 1975. During the next four years, the dividend yield first fell rapidly to its post-1968 low of 11.1 percent in 1977 and then rose to its maximum of 17.7 percent in 1979.

The industry's cost of debt financing (the after-tax corporate bond rate) followed a relatively stable growth path during the period from 1958 to 1973 (Figure 30), increasing from 2.1 percent in 1958 to 4.3 percent in 1973. However, the behavior of the industry's after-tax corporate bond rate became much more erratic after 1973. It increased 0.9 percentage points to 5.2 percent in 1974; decreased to 4.0 percent in 1976; and then rose to its maximum level of 6.0 percent in 1979.

...And Exceeded The Costs Of Manufacturing Industries Generally...

Table 10 compares the average after-tax costs of equity capital in the steel industry with that of all-manufacturing and compares the steel industry's after-tax debt cost with an average of Moody's AAA and BAA bond rates over selected peak-to-peak intervals. Once more, the data reflects a troubled industry. The average annual cost of common equity to the steel industry ranged from about 1.3 percentage points higher than all-manufacturing during the 1959-66 peak-to-peak interval to 8.5 percentage points higher during 1974-79. The industry's average annual costs of preferred equity increased more modestly, from 0.3 percentage points higher than all-manufacturing during 1959-66 to 2.8 percentage points higher during 1974-79. Similarly, the after-tax cost of debt capital, relative to the average of Moody's AAA and BAA bond rates after taxes, increased from being the same during the 1958-66 interval to being 0.5 points higher during the 1974-79 interval.

...And Exceeded The Rate Of Return On Capital.

Since the primary iron and steel industry employs a mixture of debt and equity instruments together with internal funds as sources of capital, the relative costs shown in the previous section do not tell the complete story. The actual or composite cost of capital to the industry is a weighted sum of the costs of common equity funds (both internal and external), preferred equity funds and long-term debt funds, which together comprise the industry's total sources of funds. Following established practice, the implicit cost of using internal funding is assumed to be the same as that of common equity funding, i.e. the earnings/price ratio. Figure 31 show the steel industry's weighted

TABLE 10

Average Annual After-Tax Costs Of Capital, During Selected Peak-To-Peak Business Cycles

	Business Cycle		
	1959-66	1966-74	1974-79
Earnings/Price			
Primary Iron and Steel	8.0%	11.9%	21.1%
All Manufacturing	6.7	8.6	12.6
Dividend Yield			
Primary Iron and Steel	6.3	12.9	14.9
All Manufacturing	6.0	11.1	12.1
Corporate Bond Rates			
Primary Iron and Steel	2.4	3.7	4.9
Average of Moody's AAA and BAA	2.4	3.5	4.4

SOURCE: Office of Business Analysis, U.S. Department of Commerce; Standard & Poor's; and Board of Governors, Federal Reserve Board.

after-tax cost of capital vis-a-vis its nominal after-tax rate of return to capital plus interest expense.[4] The cross-hatched area in Figure 31 represents the difference between the industry's rate of return to capital and its weighted cost of capital. This difference represents those funds which can be employed by the industry for cash dividends, debt amortization, capital modernization, etc.

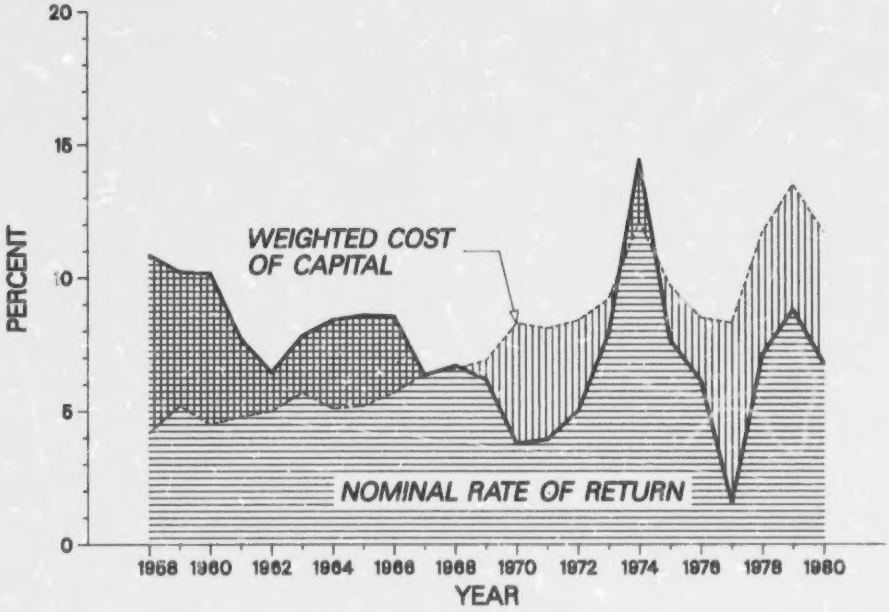
During the period 1959-66, steel enjoyed a relatively comfortable position, with its 8.5 percent average annual rate of return exceeding its average annual weighted cost of capital of 5.1 percent. Beginning in 1966, however, the industry's composite cost of capital exceeded its rate of return and, with the exception of 1974, that situation has not been altered since. Between 1966 and 1974, its average annual cost of capital was 8.0 percent, but its average annual rate of return to capital was only 7.0 percent. But during the 1974-79 cycle, the gap between costs of and returns to capital widened to 3.2 percentage points, as the average annual costs of capital increased to 10.8 percent, while the average annual rate of return to capital increased to only 7.6 percent.

---

[4] The comparisons between the cost of capital and the rate of return on capital in this section can only be considered an approximation, because the comparison is between the marginal cost of acquiring new capital assets and the average rate of return derived from all capital assets. An exact statement requires comparing the cost required to finance each unit of capital with the rate of return derived from it.

FIGURE 31

Weighted After-Tax Cost Of Capital Versus Nominal After-Tax Rate of Return To Capital, 1958-80



a/ Capital income includes interest expense.

SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, Inc.

B.4 Mini-Mills Versus Integrated-Mills

But, A "Mini" Epilogue Finishes The Story On A Brighter Note.

A bright light in the U.S. Steel industry's future is the evolution of "mini-mills" during the past two decades. As the name suggests, "mini-mills" were originally small-sized, non-integrated steel establishments. However, today's "mini-mills" have expanded considerably in size and product mix. In fact, some plants have even reached an annual capacity of approximately one million metric tons; but plant integration has been minimal. One measure of the in roads which mini-mills have made into the primary iron and steel industry is that they were estimated to be generating 3 percent of total output in 1960 but some 20 percent by 1984. Moreover, by the end of the century, they are expected to produce up to 40 percent of total U.S. steel output.

One common denominator does remain in the mini-mill concept -- the use of "state-of-the-art" technology in making steel from ferrous scrap by means of computer controlled electric-arc furnaces and continuous casting. The use of more advanced technology enables the mini-mills to maintain tight quality control, minimize labor capital, energy and material costs, and make use of a readily accessible scrap as its primary materials input.

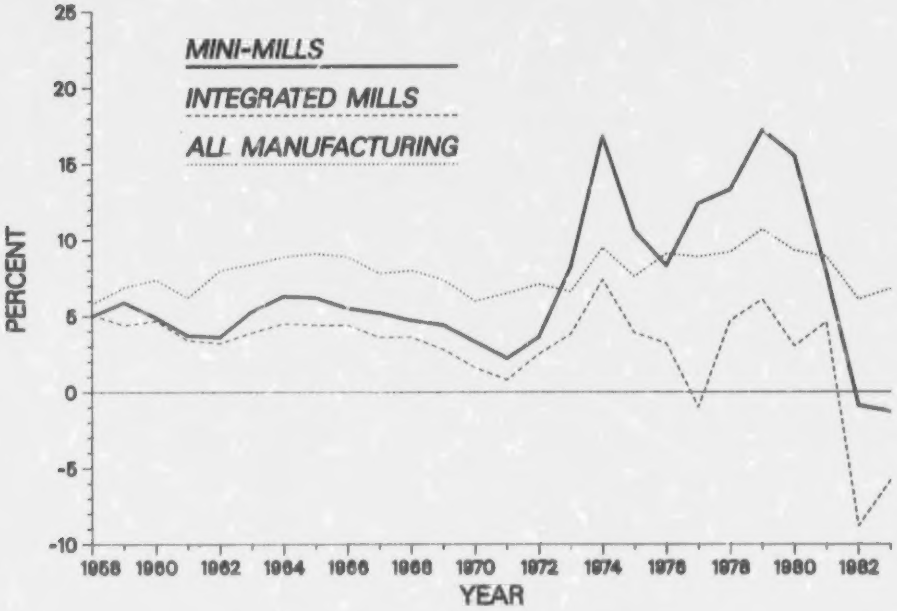
The analysis which follows is based on a sample of 13 publicly traded mini-mill companies. The data from this sample of companies provides a representative picture of the financial performance of this segment of the industry vis- a-vis their integrated mill counterparts.

While Integrated Company Profits Shrank, "Minis" Reaped Increasing Returns To Capital, 1966-79...

As noted in the preceding sections, returns to capital in the primary iron and steel industry have been in chronic decline over the past two decades -- most notably during the period from 1966 to 1983. However, as shown in Figure 32, the mini-mills have been able to consistently exceed the returns to capital in the rest of the industry.

FIGURE 32

Ratio Of Operating Profits Before Extraordinary Items And Discontinued Operations To Book Value Of Capital Stock



SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, inc.

Table 11 shows that during the 1959-66 and 1966-74 cycles, mini-mills had an average annual rate of return which was 1.1 to 1.8 percentage points higher than that of the rest of the industry. Moreover, in the 1974-79 cycle, minis were generating an average annual rate of return more than three times that of the remainder of the industry. And, while the return on capital in integrated mills was decreasing at a compound annual rate of -3.2 percent, it was increasing at a rate of 0.4 percent in mini-mills. (If the interval 1973-79 were used, the compound annual growth rate for minis would have been 8.3 percent).

TABLE 11

Comparison Of Average After-Tax Annual
Nominal Rates Of Return On Capital,
During Selected Peak-To-Peak Business Cycles

	Business Cycle			
	1959-66	1966-74	1974-79	1979-83
Mini-mills	5.2%	5.2%	13.1%	7.7
Integrated mills	4.1	3.4	4.0	-0.2

SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, Inc.

But, Returns To Capital For Both Segments Of The Steel Industry Fell Markedly In 1982 And Remained At Reduced Levels Through 1983.

Mini-mills continued to generate significantly higher after-tax rates of return than their integrated counterparts during the 1979-83 interval -- an average of 7.7 percent compared with minus 0.2 percent. Since the 1979-83 interval does not constitute a peak-to-peak business cycle, no strict comparisons can be made; however, the mini-mill average annual rate of return to capital was 5.4 percentage points lower in this interval than in the 1974-79 business cycle.

The rate of return to capital in integrated mills increased from 3.0 percent in 1980 to 4.6 percent in 1981, but the mini-mill's rate fell from 15.5 percent in 1980 to 7.8 percent in 1981 (Figure 32). However, in 1982, large decreases occurred in the rates of return to capital earned by both segments of the industry -- the rate in mini-mills fell to 0.9 percent while that of the integrated segment plummeted to its post-1958 low of minus 8.8 percent. The mini-mill rate of return decreased to its post-1958 minimum of minus 1.3 percent in 1983, while the rate of loss in integrated mills improved somewhat to minus 5.8 percent.

In 1972, Mini-Mill Returns To Capital Began To Exceed Those In All-Manufacturing And Were Consistently Higher Through 1980...

During the period from 1958-72, mini-mills exhibited an average annual rate of return that was consistently lower than the all-manufacturing rate. However, the effects of an infusion of new capital during 1968-71 altered this completely (the book value of capital stock in the mini-mill segment increased by approximately 50 percent from 1968 to 1971). Mini-mills employed this new capital to generate average annual rates of return 3 percentage points greater than those earned by manufacturing sectors overall during the 1972-80 period.

But, The All-Manufacturing Rate Of Return Has Exceeded That Of The Minis Since 1981.

As Figure 32 shows, the mini-mill rate of return fell by 7.7 percentage points to 7.8 percent in 1981, while the all-manufacturing rate fell by only 0.4 of a percentage point to 8.9 percent. With the exception of 1976, this was the first, post-1972 year in which the all-manufacturing rate exceeded that of the mini-mills. The gap between the all-manufacturing rate of return to capital and that of the minis widened further to 7.0 and 8.1 percentage points in 1982 and 1983, respectively.

Between 1958 and 1980, Similar Debt:Equity Ratios, But...

Leverage (the ratio of debt to debt plus equity) is usually defined as the amount of debt the owners of a business employ in proportion to their own contributions in financing the total assets. The term leverage is used because these funds, which are acquired at a priority of premium repayment and interest return, widen the potential swing of both gains and losses to the ownership shares. Leverage is considered to be profitable if the rate of earnings on acquired assets is greater than the going rate of interest, and unprofitable, if the rate of earnings is less than the going interest rate.

From 1958 to 1963, both segments of the steel industry employed approximately the same degree of leverage as all-manufacturing -- between 16 to 28 percent (see Figure 33). However, in 1968, the integrated-mill segment's leverage ratio jumped to 33.4 percent; and, in 1969, the mini-mills followed suit by reaching a leverage ratio of 33.9 percent. Both ratios have remained above 31 percent throughout the period 1970-80. Moreover, with the exception of the years 1973 and 1974, when there was a large increase in the leverage ratio for all-manufacturing, the leverage ratios for both the mini and integrated mill segments have remained higher than the corresponding value for all-manufacturing.

Post-1980 Ratios Are Significantly Different, And ...

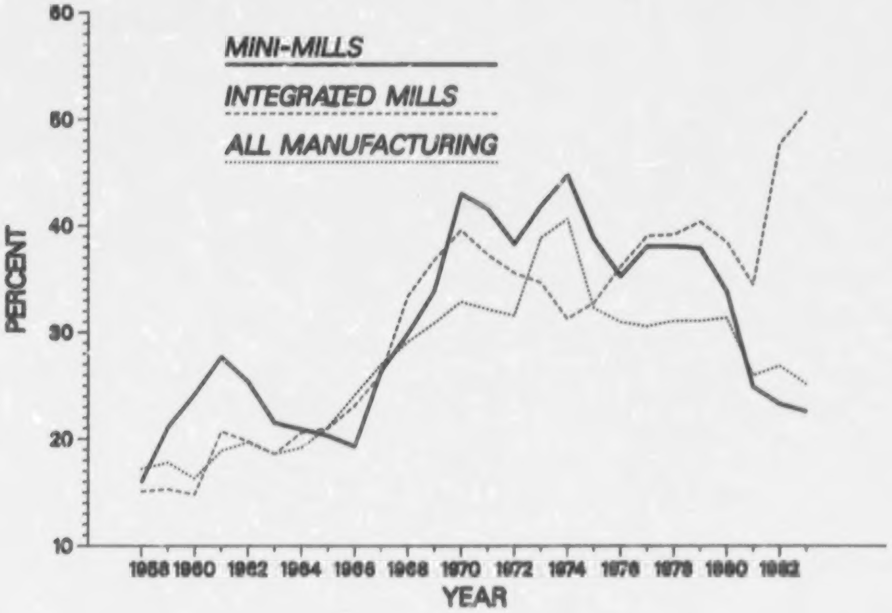
In 1981, both segments of the steel industry reduced their debt:equity ratios -- mini-mills by 9 percentage points to 24.9 percent and integrated mills by 4.0 percentage points to 34.5 percent. The 1981 all-manufacturing ratio of 26.0 percent exceeded that of the mini-mills for the first time since 1967. While the mini-mills continued to reduce their leverage ratio in both 1982 and 1983, the debt:equity ratio of their integrated counterparts rose by 13.2 percentage points to 47.7 percent in 1982 and increased an additional 3.0 percentage points to 50.7 percent in 1983.

...Mini-Mills Use Of Debt Differs Considerably From Integrated Companies...

Perhaps nothing illustrates the contrast between the financial health of the mini-mill and integrated-mill segments of the U.S. steel industry more effectively than their respective uses of long-term debt and the different results obtained from its employment. Since the lag -- between financing a capital expansion and reaping its rewards -- is much shorter for mini-mills than their integrated counterparts, mini-mills have very effectively employed long-term debt as a counter-cyclical financing device. The minis, anticipating increased demand from recovery and their superior competitive position, used debt financing as a mechanism to continue capital expansion plans right through recessions. Their integrated counterparts, by contrast, were increasingly using debt financing to amortize existing long term debt and repay interest.

FIGURE 33

Leverage Ratio:Ratio Of Debt To Debt Plus Equity 1958-80



SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, Inc.

Figure 34 clearly demonstrates how mini-mills have used debt financing during the trough phases of the 1966-74 and 1974-79 business cycles. Notice that the share of funds obtained through long-term debt was at relative maximums of 48.8 percent in 1971, 35.2 percent in 1977, and 34.6 percent in 1982. Meanwhile, the share of funds used for capital expenditures increased from 27.1 percent in 1971 to 42.0 percent in 1974 and from 33.7 percent in 1977 to 59.7 percent in 1979 (see Figure 35). In comparison, the share of funds obtained from debt issues in the integrated mill segment was only 17.9 percent in 1971, 34.7 percent in 1977, and a maximum of 57.1 percent in 1982. The share of funds used by the integrated-mill segment for capital expenditures decreased during the 1971-74 and 1977-79 intervals.

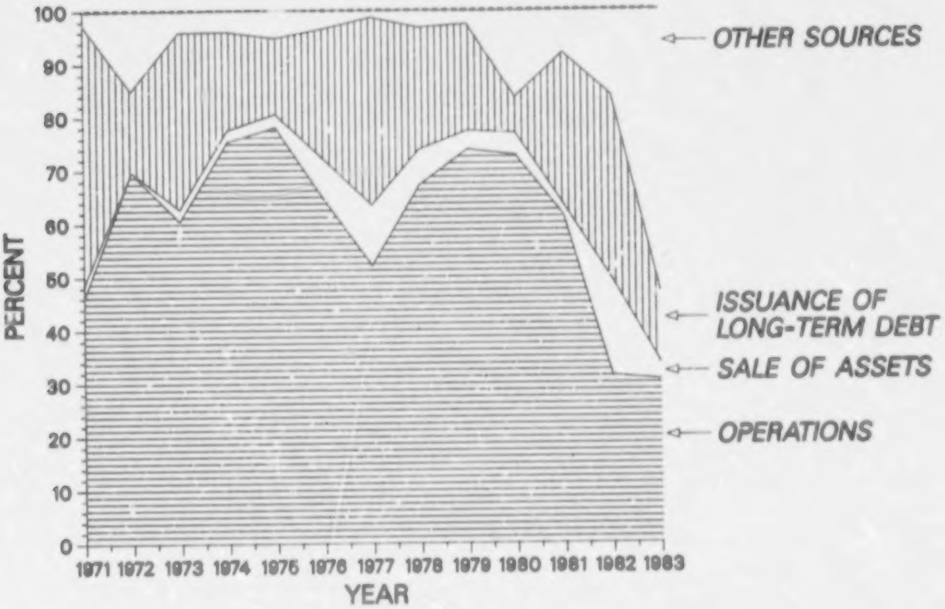
Mini-mills also used debt effectively to make acquisitions which improved their competitive position. Figure 35 shows that the share of funds used by minis for acquisitions was greater than 20 percent in both 1971 and 1977, compared with 1.1 percent for integrated mills.

Mini-mill companies' use of debt was also generally more profitable than that experienced by integrated mill companies. Between the 1967 and 1974 peak output years, the average corporate bond rate for the overall steel industry was 8.7 percent, but

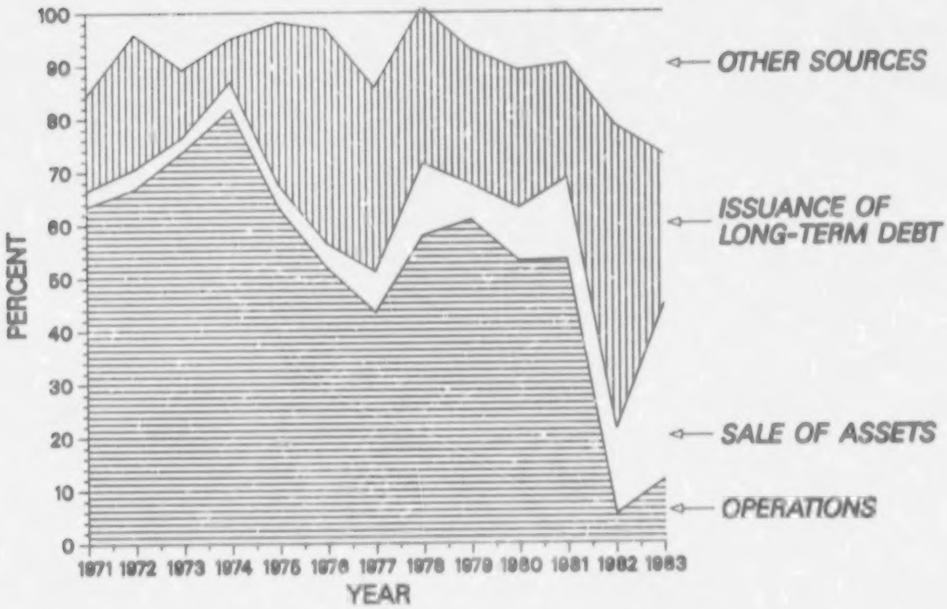
FIGURE 34

Percentage Distribution Of Sources Of Funds

Mini-mills



Integrated Mills

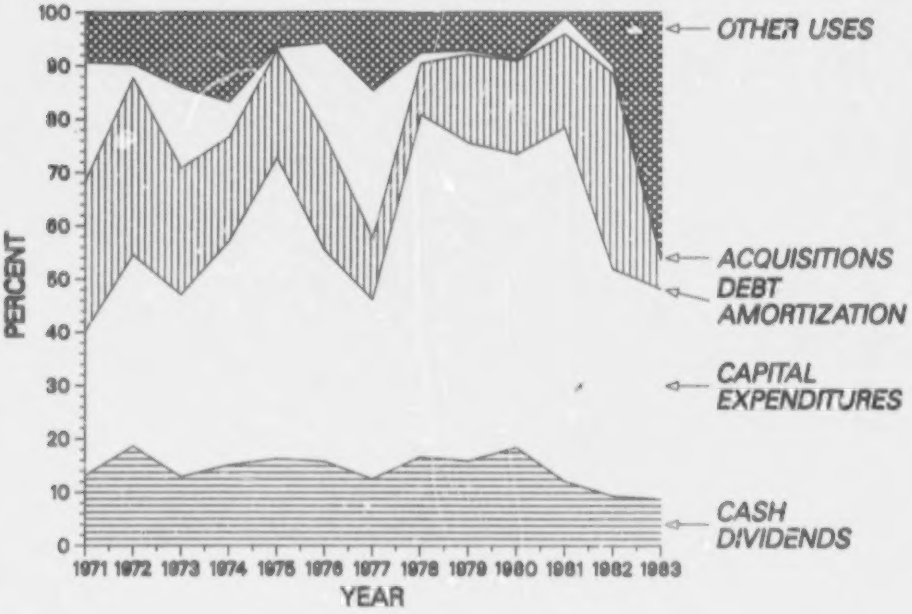


SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Service, Inc.

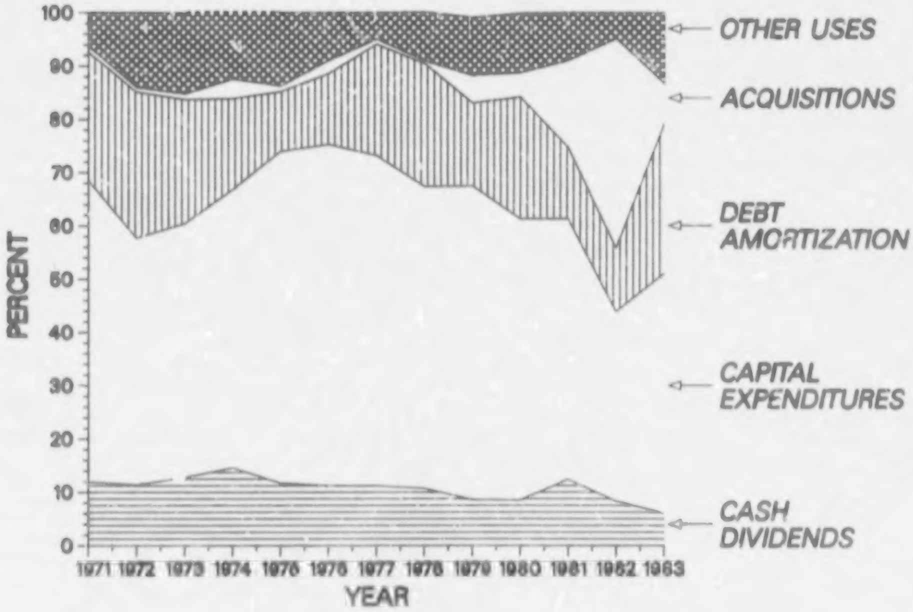
FIGURE 35

Percent Distribution Of Uses Of Funds

Mini-mills



Integrated Mills



SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, Inc.

the mini-mill's average annual rate of return on capital was only 5.2 percent and the integrated mill's rate of return was only 3.2 percent. As such, the employment of leverage appears to have been unprofitable for both segments of the industry during this period, with the mini-mills experiencing an average net loss of 3.5 percentage points and the integrated mills an average net loss of 5.5 percentage points.

During the 1974-79 cycle, this situation changed radically for the mini-mills, but not for the integrated mills. The average corporate bond rate for overall steel was 10.3 percent during this period. But, the mini-mills had an average annual rate of return on capital of 13.6 percent, while the integrated mills had an average annual rate of return on capital of only 3.9 percent. Leverage had been used by the mini-mills to effect a net gain of 3.3 percent, while the integrated mills experienced a net loss of 9.7 percent.

In summary, it is evident that mini-mills have utilized long-term debt as an effective counter-cyclical instrument to finance their continued growth; whereas, the rest of the steel industry has used long-term debt to survive.

The Market Responds With Lower Costs Of Capital...

The data shown in Table 12 reflect the reaction of the equity market to the performance of mini-mills vis-a-vis their integrated counterparts. The higher cost of both common and preferred equity to the mini-mills in the first cycle, 1959-66, is reasonable, considering their relatively small market share. The differences in the average annual costs between the new mini-mill and the established integrated-mill sectors during 1959-66 are quite small -- 0.2 percentage points for common and 0.5 percentage points for preferred.

TABLE 12

Average Annual After-Tax Cost Of Equity Capital,
During Selected Peak-To-Peak Business Cycles

	----------------Business Cycle----------------		
	1959-66	1966-74	1974-79
Earnings/Price			
Mini-mills	8.2%	10.7%	19.0%
Integrated Mills	8.0	9.2	21.5
Dividend Yield			
Mini-mills	7.5	9.4	11.8
Integrated Mills	7.0	12.8	15.7

SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, Inc.

No major change in the common stock market's evaluation took place during the 1966-74 cycle -- the mini-mill average annual earnings/price ratio was 1.5 percentage points greater than the integrated mills. However, the preferred equity market was beginning to perceive the potential of the minis; the average annual cost of preferred stock for the minis during 1966-74 was approximately 9.4 percent versus 12.8 percent for the integrated mills.

During the 1974-79 cycle, the 19 percent average annual cost of common equity to the minis was less than the 21.5 percent cost to the integrated segment. Similarly, the minis' average annual cost of preferred equity was 11.8 percent compared with 15.7 percent for their integrated counterparts. Since the corporate bond rate data for mini-mills are rather sparse, no cost comparisons were attempted. However, changes in the costs of debt financing seem to be moving in the same general direction, and at the same rate, as those of common equity.

Summary

The financial health of the overall steel industry has deteriorated steadily and markedly during the 1958-83 period. The industry's average annual after-tax nominal rate of return on capital trended strongly downward and fell from 4.2 percent during the 1959-66 period to minus 0.3 percent during the 1979-83 interval.

The industry's interest burden also increased steadily. On average, interest expense absorbed 19 cents per dollar of capital income during the 1959-66 business cycle but eighty-eight cents of each capital income dollar earned during the 1979-83 interval.

With an increasing share of internal funds being diverted to interest expense, the steel industry turned to external capital to finance capital expansion and modernization. Long-term debt provided an average of 28 percent of the industry's total funds during the 1971-83 period, reaching a high of over 56 percent in 1982. In comparison, long-term debt averaged only 17.4 percent of total funds in manufacturing industries overall between 1971 and 1983, with a maximum of 24 percent in 1975.

The uses of funds by the steel industry differed significantly from the uses of manufacturing industries overall. For example, the steel industry used, on average, 10.8 percent of its funds for cash dividends, while all-manufacturing used 15.8 percent; 20.7 percent of the steel industry's total funds were used to amortize long-term debt, while all-manufacturing used only 12 percent for this purpose; and an average of 52 percent of steel funds were used for capital expenditures, compared with 56.3 percent by all-manufacturing.

Dramatic increases also occurred in the costs of capital to the steel industry. Between 1959 and 1979, the cost of common equity capital quadrupled, the cost of preferred equity tripled and the cost of long-term debt more than doubled. Comparable increases, however, did not occur in the steel industry's rate of return on capital -- the difference between the industry's after-tax average annual nominal rate of return (including interest expense) on capital and its weighted cost of capital dropped from a plus 3.3 percentage points during the 1959-66 business cycle to a minus 3.0 percentage points in the 1974-79 cycle.

One bright light in the U.S. steel industry's future is the evolution of mini-mills during the past two decades. Mini-mills have consistently generated higher returns on capital than their integrated counterparts. For example, the mini-mills average annual nominal rate of return on capital was 1.1, 1.8, 9.1, and 7.9 percentage points higher than that of integrated mills during the 1959-66, 1966-74, 1974-79, and 1979-83 peak-to-peak intervals, respectively. Moreover, between 1972 and 1980, the nominal rate of return on capital in the mini-mill segment averaged 3 percentage points greater than that of manufacturing industries overall.

C. LABOR INPUTS

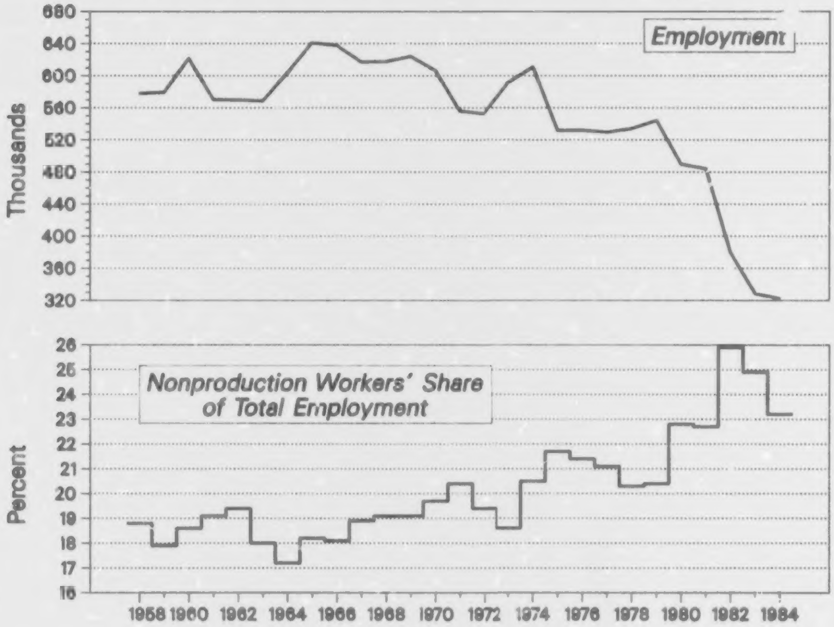
C.1 Employment And Hours

Total Employment In The Iron & Steel Industry Has Declined, And Nonproduction Workers Have Become A Larger Segment Of The Workforce.

Between the peak output years of 1959 and 1966, total employment in the primary iron and steel industry grew by 58.4 thousand workers, reaching a level of 637.9 thousand in 1966. After this year, however, each business cycle peak found employment at a lower level; as the top chart in Figure 36 shows, employment declined to 624.3 thousand in 1969, 611 thousand in 1974, and to 544.4 thousand in 1979. The general contraction in the industry accelerated after 1979: total employment dropped by more than 40 percent and 200 thousand jobs were lost by 1934.

FIGURE 36

Total Employment (Thousands) And
Nonproduction Workers As A Percent Of Total Employment



SOURCE: Bureau of the Census and Office of Business Analysis, U.S. Department of Commerce.

The drop in the industry's employment has been mostly caused by changes in production worker employment, as Table 13 shows; between 1966 and 1974, employers were adding nonproduction workers and reducing the number of production workers. From 1974 to 1979, declines in nonproduction worker employment slightly exceeded those of production workers, but thereafter disproportionate declines in production worker employment occurred. The result was a general rise in nonproduction worker's share of total employment, depicted in the bottom chart of Figure 36.

TABLE 13

Percent Change In Employment Over The Business Cycle

Peak Years	All Workers	Production Workers	Nonproduction Workers
1959-66	10.1%	9.8%	11.3%
1966-69	-2.1	-3.4	3.4
1969-74	-2.1	-14.2	5.0
1974-79	-10.9	-10.8	-11.2
1979-84	-40.8	-42.9	-32.6

SOURCE: Bureau of the Census, U.S. Department of Commerce.

Production Workers Are Averaging Fewer Hours Worked Per Year...

As iron and steel industry employment declined between 1958 and 1980, so too did hours worked by production workers -- and at a greater rate. Production worker man-hours dropped at a six percent linear trend during this period, relative to the 3.6 percent downward trend in production worker employment.

The data show that since the 1960's there has been a general trend in the manufacturing sector toward fewer hours-worked per production worker, and the iron and steel industry has been no exception. By 1980, successive peaks in the annual hours-worked per production worker series for iron and steel had not regained the level reached in 1969, at 2,018 hours-worked. The trend in manufacturing has been less volatile, but has still been downward since 1968. In part these drops are due to reductions in plant operating rates and capacity utilization; another important factor has been the rise in hours-paid but not worked.

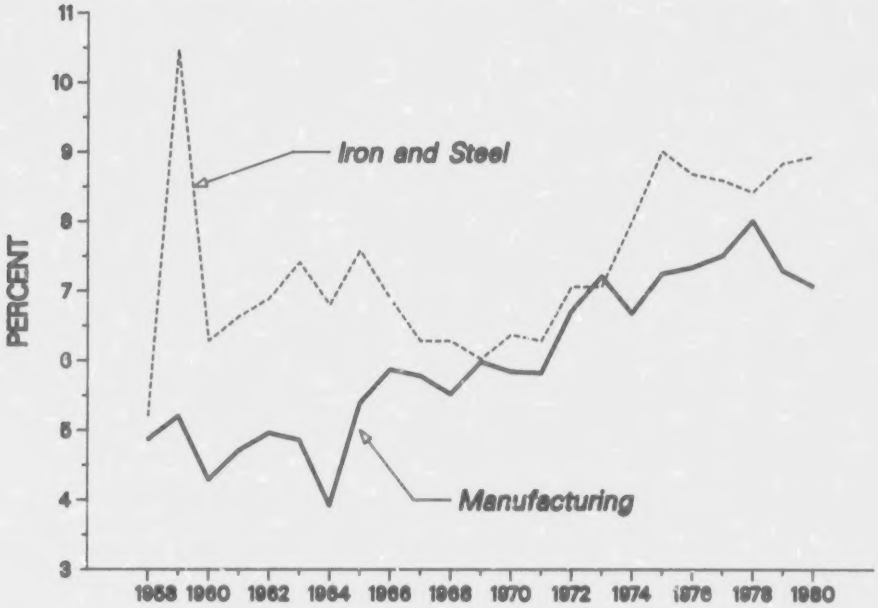
...While The Number Of Hours Paid, But Not Worked, Is Rising

Time off from the job with pay has always been an attractive fringe benefit; most companies have policies granting civic and personal leave, paid vacations, and holidays off. Among production workers in the highly-unionized iron and steel industry, paid timeoff has become an increasingly important component of the paycheck: the number of hours paid but not worked (per production worker) rose from roughly six percent of all hours paid in 1958 to nearly ten percent in 1980. In the manufacturing sector as a whole, this ratio rose over the same period at a much slower rate -- from five percent in 1958 to only seven percent by 1980.

As Figure 37 below illustrates, the ratio of hours paid to those worked has been noticeably above average since the early 1970's. This may have been related to the institution of the Experimental Negotiating Agreement, in 1973, by which labor unions in this industry signed a no-strike clause in return for a compensation package that stipulated a guaranteed three percent annual wage increase, cost-of-living-adjustments annually, and productivity bonuses. Prior to the institution of ENA, the hours-paid to hours-worked gap fluctuated around a mean of 7.3 percent; the post-1973 period saw this gap rise to ten percent in 7 years.

FIGURE 37

Ratio Of Hours-Paid To Hours-Worked, Per Production Worker



SOURCE: Bureau of the Census, U.S. Department of Commerce; Bureau of Labor Statistics, U.S. Department of Labor.

C.2 Labor Quality: Demographic Characteristics Of The Workforce

The technical and productivity growth potential of any industry is closely related to the quality of its workforce. The exact nature of this relationship is not well understood, but there is a consensus that the quality of the labor force is a major factor in an industry's awareness of new techniques, and in its ability to effectively absorb and utilize them in its production process. Briefly stated, labor quality is a combination of the workforce experience and technical expertise which workers bring to the job as well as their orientation and adaptability to technological change in the production process.

Workforce experience is of several kinds; each contributes to productivity growth in different degrees. For example, a high level of general workforce experience contributes to workplace discipline, dependability, and good work habits. But a high level of occupation-, industry-, or company-specific experience is more critical to achieving the level of technical proficiency required for an industry's long-term productivity growth.

The educational characteristics of an industry's workforce are considered particularly important. In summarizing the current research on the dynamics of the innovation process, Utterback, for example, concludes:

> Personal contacts, education and experience constitute the largest portion of information used in orginating new ideas for innovation. The data from these studies suggest that education is the primary avenue through which basic finds are translated into engineering practice. 1/

In what follows, we examine the age, sex, education, and occupation attributes of employees in the primary iron and steel industry. Both the absolute proportions of each attribute and their growth over time are important indicators of the levels and trends in labor quality. The proportions of women and youth in the workforce, for example, reflect the experience dimension of the workforce 2/; educational attainment and occupational distribution characteristics reflect the level of technical expertise; and the proportions of workers 25-44 years old and 55-and-over serve as positive and negative indicators, respectively, of how receptive and adaptive the industry's workforce is likely to be to cost-saving technical changes.

Workforce Experience Indicators

The use of the proportion of females and its growth over time as indicators of potential deterioration in the overall experience level of the workforce is unquestionably controversial; nevertheless, most observers note that males have historically maintained a more permanent and unbroken attachment to the labor force. Thus, men and women, who are similar with respect to other relevant demographic characteristics -- age,

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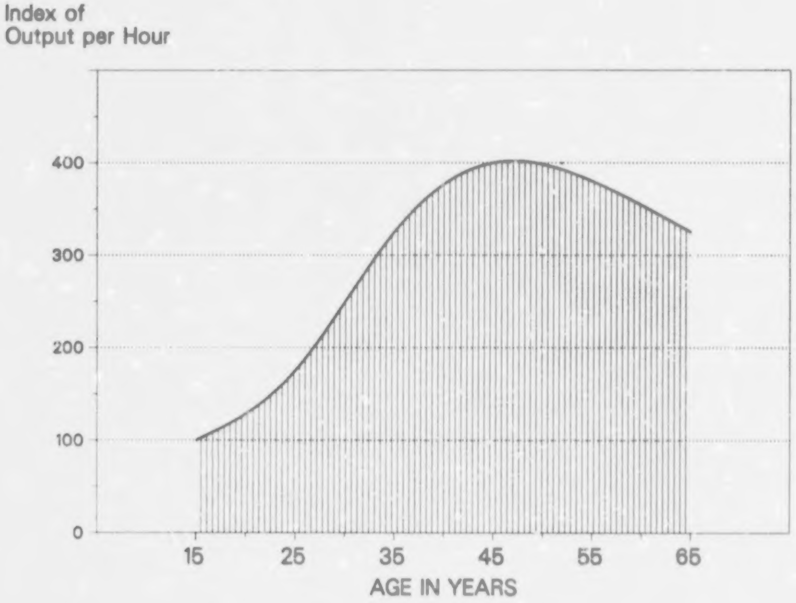
1/ See J.R. Utterback, "Innovation in Industry and Diffusion of Technology," **Science,** Vol. 183, February, 1974, pp. 620-626. For further background, see A. H. Rubenstein, "The Role of Imbedded Technology in Industrial Innovation," in **Special Study on Economic Changes, Volume 3, Research and Innovation: Developing A Dynamic Nation,** Joint Economic Committee, December 1980.

2/ See, for example, R.E. Hall, "The Importance of Lifetime Jobs in the U.S. Economy," **NBER Working Paper,** No. 560, National Bureau of Economic Research, October 1980.

education, and occupation -- are likely to have much different degrees of on the job experience. Economic studies suggest that between 4.0 and 10.0 percent of the decline in the rate of productivity growth experienced by the U.S. economy since the mid-sixties is attributable to the rapid growth in the proportions of females and young workers in the workforce. 3/

The "s-curve" in the figure below illustrates why the age profile of the workforce, and changes in this profile, can have important implications for an industry's productivity performance. The figure can be interpreted in two ways: either as the output per hour schedule of a typical worker over his working life, or as the the output per hour schedule for the entire age distribution of an industry's workforce. Viewed from either perspective, however, the conclusions are the same.

Life-Cycle Productivity Profile
Of An Average Worker: An Illustration



The figure shows that productivity of the youngest workers (under 25 years) grows slowly, as these workers develop greater on-the-job experience and complete their formal education. As they begin to work full-time, these workers develop a more thorough understanding of their industry's production process, and learn how to creatively and effectively apply their formal education to that process; their productivity begins to grow more rapidly once they reach the 25 to 44 year-old age cohort. Subsequently, these workers enter the mature stage (between 45 and 54 years-old) of their life-cycle productivity profile; productivity continues to grow but at a slower rate, as their technical knowledge becomes outdated and their physical energy and willingness to be receptive to and adapt to technical change wanes. Finally, in the last (55 years and over) stage of the life-cycle productivity profile, the worker's productivity may actually decline due to physical and/or mental impairments.

3/ This conclusion does not imply any innate difference between the sexes; it also does not rule out the possibility that discrimination may underly the wage differential between men and women in the workforce.

The level and growth of an industry's life-cycle productivity curve have important productivity growth implications:

- Industries which experience growth in the share of their workforce accounted for by employees at the extremes of the age distribution -- 14-24 year-olds and 55 + year-olds -- will, other things equal, also experience declining productivity growth, while those industries experiencing disproportionate growth in the 25-44 age class will experience increasing productivity growth.

- Industries with relatively high proportions of 14-24 and over-55 year-old workers will, other things equal, experience lower productivity growth than industries which have low proportions of such workers in their workforce, with the converse true in the case of 25-44 year-olds.

Tables 14 and 15 below show the sex and age profiles of the workforce in the iron and steel industry compared with those found in overall manufacturing.

TABLE 14

The Female Share Of Employment And Its Growth:
Iron And Steel Vs. All-Manufacturing

A. EMPLOYMENT SHARES a/

	Total Employment		**Production Workers**		**Nonproduction Workers**	
Peak Year	Steel	Manufacturing	Steel	Manufacturing	Steel	Manufacturing
1959	5.6%	24.9%	1.7%	23.1%	22.7%	29.1%
1966	6.9	25.8	2.8	24.8	22.7	28.0
1974	5.6	28.0	2.6	26.6	17.5	31.0
1979	8.2	30.9	4.0	28.7	23.4	35.3

B. GROWTH RATE OF EMPLOYMENT SHARES b/

	Total Employment		**Production Workers**		**Nonproduction Workers**	
Peak-To-Peak Interval	Steel	Manufacturing	Steel	Manufacturing	Steel	Manufacturing
1959-66	3.1%	0.5%	7.2%	1.0%	0.0%	-0.5%
1966-74	-2.7	1.2	-0.9	1.0	-3.2	1.5
1974-79	7.8	1.6	9.0	1.3	6.0	2.2

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a/ Shares shown for all-manufacturing refer to corresponding peak-output years: 1959, 1966, 1973, and 1979.

b/ Compound annual growth rates. For all-manufacturing, growth rates refer to corresponding peak-to-peak intervals: 1959-66, 1966-73, and 1973-79.

SOURCE: Bureau of the Census and Office of Business Analysis, U.S. Department of Commerce.

Female Employment Is Concentrated In Nonproduction Jobs — Though Most Growth Has Increases In Production Employment.

In 1979, female workers accounted for one out of every twelve employees in the iron and steel industry, a near-doubling in their numbers since 1958. As a group, they generally shared in the industry's growth during the 1959-66 period, and its' decline during 1966-74; thereafter, however, female workers' employment levels have been running counter to the steel industry trend. During the 1974-79 period, while total employment was declining at a 2.3 percent compound rate, female employment was rising by a 5.4 percent compound rate. The industry lost 66,600 workers during this period, but employment of females was up by 10,200 workers.

For the most part, females in this industry have held nonproduction jobs. Table 14 shows that female workers in the steel industry have historically comprised one of every five nonproduction jobs, while within production jobs they numbered less than one in twenty. It is the increase in female production employment, however, that has provided much of the growth in their share of total employment, as the lower half of Table 14 shows.

In the manufacturing sector overall, female workers were also more likely to be found in nonproduction jobs, but not to the extent as in iron and steel. For example, in 1979 females in manufacturing accounted for 35.3 percent of nonproduction employment and 29 percent of production employment vs. 23.4 percent and 8.2 percent, respectively, for iron and steel. By 1980, females accounted for one of every three workers in the average manufacturing sector, and one of every ten workers in iron and steel.

In summary, since the mid-1970's the steel industry has absorbed a disproportionate growth of female workers in general, and of female production workers in particular. Because many of these workers likely had both limited general work experience and no experience in the production of iron and steel the rapid growth in female employment after 1974 was likely a factor in the industry's productivity growth decline (see Part III, Section B.3).

Older, More Experience Workers Predominated In The Steel Industry — Especially Among Nonproduction Jobs.

The iron and steel industry has generally had an older workforce profile than the manufacturing sector as a whole; Table 15 shows that the employment shares within both production and nonproduction worker classes were skewed toward the 45-54 and 55+ year-old groups.

The proportions of 25-44 year-olds in the steel industry have been nearly identical to the manufacturing average; thus over-representation of older workers meant small shares for the youngest and most inexperienced group -- those workers aged 14-25 years. Among production workers, however, younger workers were the only age group to consistently increase their proportions over the 1959-79 period -- and by 1979 their share equalled that of the 55+ cohort. Given the link between workforce experience and labor productivity discussed at the beginning of this section, it is significant that the most inexperienced age class increased in proportion during the steel industry's post-1974 productivity decline.

In contrast, changes in the age distribution of the nonproduction workforce appear to have raised the experience level of the steel industry. The 14-24 year-old's share has declined since 1966, and since 1974 fell at a 2.9 percent annual rate, reach a level of 11.5

TABLE 15

Percent Distribution Of Employment, By Age Group And Its Growth Between Peak-Output Years: Primary Iron And Steel Industry Vs. All-Manufacturing

A. EMPLOYMENT SHARES

	Iron and Steel				Manufacturing			
	1959	1966	1974	1979	1959	1966	1973	1979
Production Workers:	100%	100%	100%	100%	100%	100%	100%	100%
14-24 Years-old	9.5	11.4	14.8	15.8	13.4	16.3	21.3	22.7
25-44 Years-old	50.8	45.1	43.3	46.0	50.2	45.1	43.7	46.7
45-54 Years-old	23.8	26.1	25.1	22.1	22.1	22.8	20.6	17.2
55 + Years-old	16.0	17.4	16.8	16.0	14.7	15.7	14.4	13.5
Nonproduction Workers:	100%	100%	100%	100%	100%	100%	100%	100%
14-24 Years-old	14.3	15.2	13.3	11.5	17.4	17.9	18.9	16.8
25-44 Years-old	49.4	46.6	46.6	50.5	51.0	48.0	46.7	51.0
45-54 Years-old	21.6	23.2	25.4	22.4	18.9	20.3	20.7	18.4
55 + Years-old	14.7	15.0	14.6	15.7	12.8	13.7	13.8	13.7

B. GROWTH RATE OF EMPLOYMENT SHARES [a]

	Iron and Steel			Manufacturing		
	1959-66	1966-74	1974-79	1959-66	1966-73	1973-79
Production Workers:						
14-24 Years-old	2.6%	3.3%	1.3%	2.8%	3.9%	1.1%
25-44 Years-old	-1.7	-0.5	1.2	-1.5	-0.4	1.1
45-54 Years-old	1.3	-0.5	-2.5	0.4	-1.4	-3.0
55 + Years-old	1.2	-0.4	-0.9	0.9	-1.2	-1.1
Nonproduction Workers:						
14-24 years-old	0.9%	-1.7%	-2.9%	0.4%	0.8%	-1.9%
25-44 Years-old	-0.8	0.0	1.6	-0.8	-0.4	1.5
45-54 Years-old	1.0	1.1	-2.5	1.0	0.3	-1.9
55 + Years-old	0.2	-0.3	1.5	1.0	0.1	-0.1

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[a] Compound annual rates.

SOURCE: Bureau of the Census and Office of Business Analysis, U.S. Department of Commerce.

percent in 1979. Nonproduction workers in the more experienced age groups -- 45-54 and 55+ -- roughly maintained their historical levels (22 percent and 15 percent, respectively) which were well above the manufacturing averages.

Indicators Of Workforce Orientation To Technical Change

Age — A Two-Edged Labor Quality Indicator.

Although the rising percentage recorded by the oldest members of the steel industry is a plus for the experience dimension of its workforce, there is considerable evidence that a high and/or growing proportion of 55 + year-old workers -- those most likely to be past their creative and technical prime -- is a negative factor with respect to an industry's receptiveness to potential cost-saving technical changes and to its ability to adapt to these changes.

Since the mid-to-late sixties, for example, highly-educated scientists and engineers in the 25-44 year-old age group have been increasingly leaving jobs previously held in mature and declining industries, such as autos and steel, for jobs in newer industries with a greater appetite for entrepreneurship and risk-taking. One of the primary reasons cited for this exodus is that the mature, "smoke-stack" industries are dominated by an older management that is not receptive to new technologies and innovations, while the newer industries offer a business environment and culture that accommodates the creative needs and aspirations of the dynamic and technology orientated younger professionals. Over this same period, recruiters for the mature industries have been encountering increased resistance from new college graduates. 4/

Viewed from this perspective, the consistently above-average shares of 55+ workers in the steel industry -- among both production and nonproduction workers -- must be interpreted as a negative development. Further, the post-1974 growth in this group's share of nonproduction employment occurred at a time when the share for manufacturing overall was falling by 0.1 percent annually. It is perhaps no coincidence that the industry's rate of productivity growth was highest between 1959 and 1974, when the over-55 segment of the nonproduction workforce was growing most slowly, and that productivity growth declined after 1974 when this cohort grew fastest.

Educational Attainment In Iron And Steel Closely Followed The Trends In All - Manufacturing

In general, educational attainment in the iron and steel industry followed the trends in aggregate manufacturing. In 1958, 63 percent of the workers in the industry had not completed a high school education. Twenty-seven percent had graduated from high school, and roughly ten percent had some college education. By 1980, the shift toward higher education had left only 30 percent of iron and steel's workers without high school diplomas; 48 percent had completed a high school education, and the remainder had some additional education. The number of workers with college experience had doubled -- and those with post-graduate education had tripled.

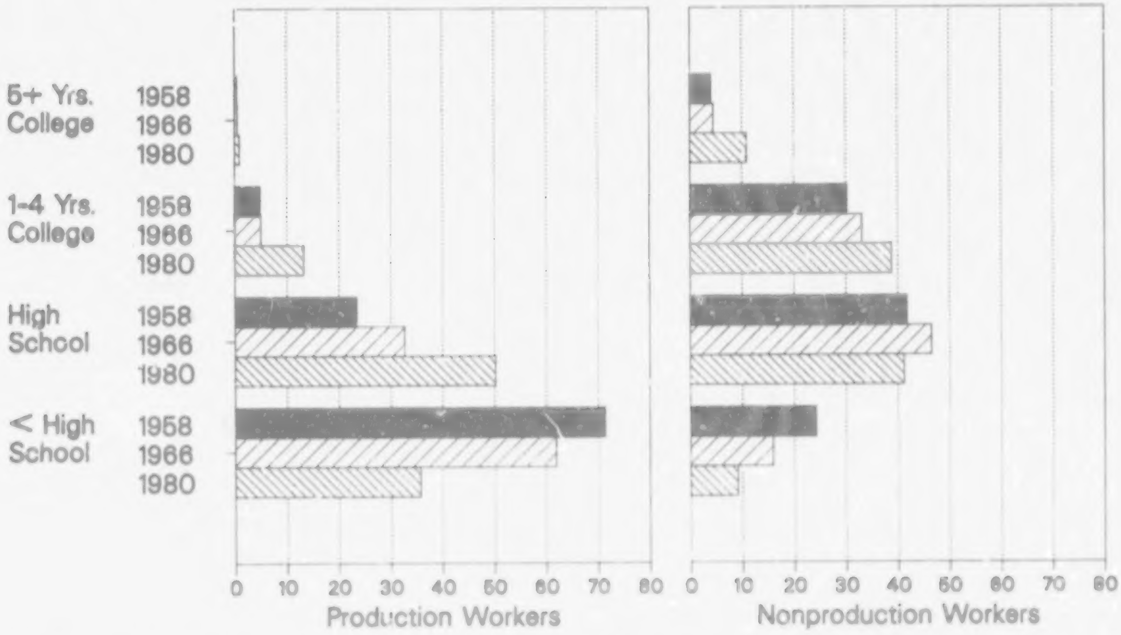
4/ See, for example, Thomas O'Boyle, "U.S. Basic Industries Are Hindered By Loss By Scientific Talent," **Wall Street Journal**, July 27, 1984, p.1; "Carnegie - Mellon University's Records Chronicle Ups and Downs of Industries," **Wall Street Journal**, July 27, 1984, p.16; and "The Toughest Job in Business," **Business Week**, Feb. 25, pp. 51-52.

Trends in educational attainment differed markedly among occupational groups. Production workers with a high school education doubled in number, from 23 percent of the workforce in 1958 to 50 percent in 1980. Figure 38 illustrates this predominance of high school completion among production workers, and the doubling since 1958 of the number of production workers with college experience. The bulk of the growth in the latter group was among those completing 1-3 years of college; college graduates (4 years) rose from one percent to roughly three percent of all production workers in the iron and steel industry between 1958 and 1980.

Among nonproduction workers, the most noticeable trend was the further decline in the number of workers without high school educations; the high school graduates remained at about two out of every five nonproduction workers. The cohort with college experience was roughly equivalent in size to that of high school graduates by 1980. The largest growth occurred among those with postgraduate experience; as Figure 38 shows, their numbers more than doubled, from four percent in 1958 to 11 percent in 1980. This trend matched that of the manufacturing sector as a whole.

FIGURE 38

Educational Attainment, By Type Of Worker



SOURCE: Bureau of the Census and Office of Business Analysis, U.S. Department of Commerce.

The Predominance Of Nonproduction Workers Was Caused By The Shift Toward A More Technically-Advanced Workforce

As noted in Section C.1, the iron and steel industry experienced a shift toward nonproduction workers in its ranks, even as overall employment declined. This shift has specifically been toward workers in the "Professional, Technical, and Kindred" class, and

away from the more unskilled classes of production workers. Technical advances in the industry have created a need for engineers, scientists, and other technical workers.

Among production workers, the only significant growth has come in the "Operatives" category; these workers perform such tasks as machine operation, assembly, and heavy equipment operating. The "Laborers" category has declined markedly, no doubt due in part to increases in education and training levels over time. The shares held by "Craftsmen" and "Service Workers" (Security guards, food service workers, health workers, etc.) remained stable. Among nonproduction workers, only the "Professional, Technical, and Kindred" category has experienced strong growth. Table 16 shows the comparative occupational distribution for selected years.

TABLE 16

Percent Distribution Of Employment, By Occupation Group

	Primary Iron And Steel				Manufacturing			
	1959	1966	1974	1979	1959	1966	1973	1979
Total Employment	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Production Workers	81.7	83.3	81.8	81.8	76.4	76.0	75.4	73.6
Nonprod. Workers	18.7	16.7	18.2	18.2	23.6	24.0	24.6	26.4
Production Workers	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Craftsmen	38.1	36.9	39.6	39.5	27.3	25.8	27.1	29.3
Operatives	36.2	43.9	43.9	45.2	60.3	64.0	61.8	59.1
Service Workers	2.7	3.6	3.9	3.5	2.5	3.0	3.4	3.3
Laborers	22.9	15.6	12.7	11.9	9.9	7.2	7.7	8.3
Nonprod. Workers	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Professionals	26.1	29.3	30.3	28.6	25.4	29.0	28.2	28.4
Managers	15.9	16.0	19.2	19.8	21.9	21.5	23.3	25.3
Clerical Workers	53.7	50.6	46.1	47.4	40.4	38.4	38.3	38.5
Sales Workers	4.3	4.2	4.4	4.2	12.4	11.2	10.3	7.8

SOURCE: Bureau of the Census and Office of Business Analysis, U.S. Department of Commerce.

Above-Average Experience Levels, But Technical Expertise Levels Equivalent To All-Manufacturing.

Table 17 summarizes the workforce experience and technical orientation/expertise characteristics of the iron and steel industry, and compares these characteristics with those of all-manufacturing. The relatively high levels of experience among workers in iron and steel is indicated by the first half of the Table. The proportions of production workers who were female or under-25 -- indicators of relative workforce inexperience -- were far below the manufacturing average in all periods. Similarly, these same proportions of nonproduction employment were also below the all-manufacturing average in all peak-output years.

However, the technical orientation characteristics of iron and steel's workforce were relatively average, as the bottom half of Table 17 shows. At every peak-output year, both production and nonproduction workers in the 25-44 year-old age group -- those most likely to be at the productive peak of their careers and to be most receptive to technical change -- comprised roughly similar proportions of the workforce in the iron and steel industry and manufacturing overall. Workers in the 55-years-and-over age category -- those most likely to be past their peak productivity years and to be less receptive to technical change -- made up larger segments of the iron and steel industry than of all-manufacturing, and, among nonproduction workers, were increasing at an above-average rate after 1974.

Workers in the iron and steel industry tended to possess lower than average levels of technical expertise. Production workers in this industry had slightly lower percentages of both high school completion and college experience 5/ than did workers in manufacturing overall; and, consistently lower percentages of the production workforce in iron and steel were concentrated in highly-skilled craftsmen or machine operative occupations than in manufacturing industries overall. Finally, the technical expertise of nonproduction workers in the iron and steel industry was roughly equivalent to the all-manufacturing levels.

5/ The term "college experience" here is used to describe workers with one or more years of college.

TABLE 17

Comparison Of Selected Labor Quality Indicators During Peak-Output Years

	Workforce Proportions a/				Compound Annual Growth		
	1959	1966	1974	1979	1959-66	1966-74	1974-79
			WORKFORCE EXPERIENCE				
Production Workers:							
Females							
Iron and Steel	1.7	2.8	2.6	4.0	7.2	-0.9	9.0
Manufacturing	23.1	24.8	26.6	28.7	1.0	1.0	1.3
14-24 Years-old							
Iron and Steel	9.5	11.4	14.8	15.8	2.7	3.3	1.3
Manufacturing	13.4	16.3	21.3	22.7	2.8	3.9	1.1
Nonproduction Workers:							
Females							
Iron and Steel	22.7	22.7	17.5	23.4	-0.3	-3.2	6.0
Manufacturing	29.1	28.0	31.0	35.3	-0.5	1.5	2.2
14-24 Years-old							
Iron and Steel	14.3	15.2	13.3	11.5	0.9	-1.7	-2.9
Manufacturing	17.4	18.0	18.9	16.8	0.5	0.7	-1.9
			WORKFORCE TECHNICAL ORIENTATION/EXPERTISE				
Production Workers:							
25-44 Years-old							
Iron and Steel	50.8	45.1	43.3	46.0	-1.7	-0.5	1.2
Manufacturing	50.2	45.2	43.7	46.7	-1.5	-0.5	1.1
55 + Years-old							
Iron and Steel	16.0	17.4	16.8	16.0	1.2	-0.4	-0.9
Manufacturing	14.4	15.7	14.4	13.5	0.9	-1.2	-0.1
High School Graduates							
Iron and Steel	23.6	32.7	44.3	50.0	4.8	3.9	2.5
Manufacturing	24.2	33.8	41.7	46.5	4.9	3.0	1.8
1 + Years of College							
Iron and Steel	5.2	5.4	9.2	11.8	0.5	6.8	5.3
Manufacturing	6.1	6.3	9.7	12.8	0.5	6.4	4.7
Craftsmen or Operatives							
Iron and Steel	74.3	80.8	83.4	84.7	1.2	0.4	0.3
Manufacturing	87.6	89.8	88.9	87.8	3.5	-0.1	-0.2
Nonproduction Workers:							
25-44 Years-old							
Iron and Steel	49.4	46.6	46.6	50.5	1.6	0.0	-0.8
Manufacturing	51.0	48.0	46.7	51.0	-0.8	-0.4	1.5
55 + Years-old							
Iron and Steel	14.7	15.0	14.6	15.7	0.2	-0.3	1.4
Manufacturing	12.8	13.7	13.8	13.7	1.0	0.1	-0.1
Four Years of College							
Iron and Steel	13.5	15.5	16.9	17.8	1.9	1.1	1.1
Manufacturing	12.7	16.2	17.0	19.2	3.5	0.7	2.0
With Advanced Degrees							
Iron and Steel	4.0	4.5	7.8	9.2	1.5	7.1	3.3
Manufacturing	6.0	6.3	8.2	9.9	0.7	3.8	3.2
Professional/Technical							
Iron and Steel	26.1	29.3	30.3	28.6	1.7	0.4	-1.1
Manufacturing	25.4	29.0	28.2	28.4	1.9	-0.4	0.1

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a/ Proportions shown for manufacturing are for the corresponding peak-output years: 1959,1966,1973 and 1979,and the growth rates are for the corresponding peak-to-peak intervals: 1959-66,1966-73 and 1973-79.

SOURCE: Office of Business Analysis, U.S. Department of Commerce.

C.3 Labor Cost: Trends In Worker Compensation

Unit Labor Costs Tripled Since 1958, with Much of the Growth After 1973...

By 1980, the labor cost required to produce a single unit of output in the iron and steel industry was three times its 1958 level -- exceeding the rise for the manufacturing sector as a whole, where the unit labor cost was twice its 1958 level.

What triggered the dramatic rise in unit labor costs for this industry was the uninterrupted growth in labor compensation coupled with the production declines which occurred in the late 1970's. Table 18 shows the result.

After 1974, iron and steel industry production was declining at an average rate of nearly three percent per year, while labor compensation was climbing by nearly nine percent; the labor cost per unit of output thus rose 13 percent annually, and by 1980 was double its 1974 level.

...and Unit Labor Cost Increases Were Largely Due to Unprecedented Growth in Labor Compensation.

Though the jump in unit labor costs in the 1970's resulted partly from a drop in the number of "units" over which costs could be spread, the growth in labor compensation in the iron and steel industry was noteworthy: on a per-employee basis, iron and steel's compensation growth averaged 11 percent per year after 1974, compared with manufacturing's 9 percent average annual growth. In dollar terms, iron and steel's compensation per worker rose from $17,622 in 1974 to $32,518 in 1980; for the manufacturing sector, compensation per worker rose from $11,958 in 1974 to $20,017 in 1980.

TABLE 18

The Components Of Unit Labor Cost Growth

Period	Real Output	Total Compensation	Unit Labor Cost 6/
1959-66	4.7%	4.7%	0.1%
1966-74	2.0	7.9	6.0
1974-79	-2.9	8.8	13.2

SOURCE: Office of Business Analysis, U.S. Department of Commerce.

6/ The final section of this paper also discusses these changes in unit labor costs, but computes average percent change in a slightly different manner; in that section, average percent changes in unit labor costs are: 1959-66, 0.1 percent; 1966-74, 5.7 percent; and 1974-79, 12 percent.

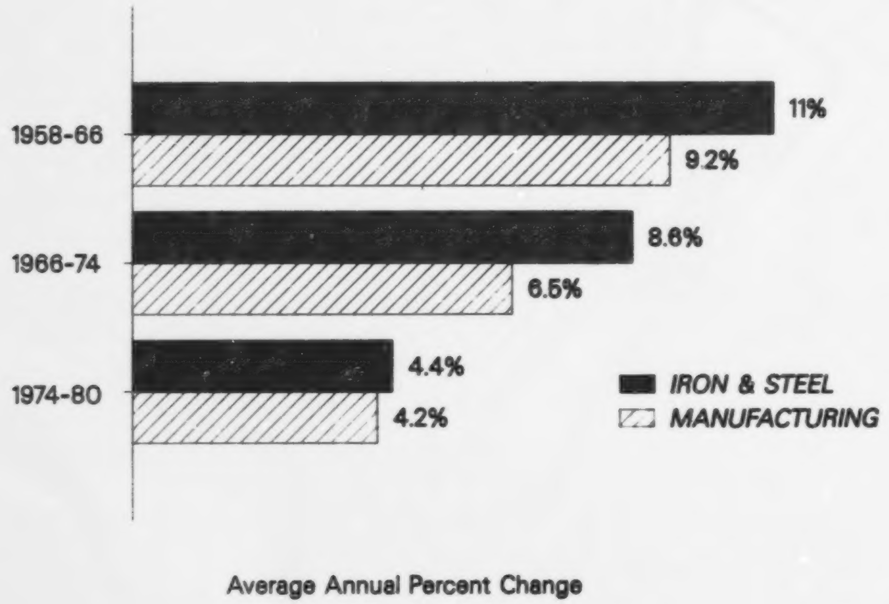
The 1973 Experimental Negotiating Agreements Were Followed by Steep Increases in Production Worker Compensation

The steep climb in labor compensation began in 1971, as the devaluation of the dollar and the Voluntary Restraint Agreements (which limited shipments from Japan and the EEC countries between 1969 and 1974) reduced, if only briefly, the intensity of foreign competition on the U.S. iron and steel industry. Further, in 1973 the Experimental Negotiating Agreements (ENA) were instituted, guaranteeing production workers in the iron and steel industry a three percent annual wage increase, cost-of-living-adjustments, and productivity bonuses in return for a no-strike pledge.

The data show that compensation per production worker grew thereafter at an average annual rate of 11 percent each year, up to 1980. This growth rate exceeded both the 9.3 percent average annual growth in the Consumer Price Index and the all-manufacturing compensation growth rate of 9.2 percent for the same period (see Figure 39).

FIGURE 39

Growth In Compensation Per Production Worker: Iron And Steel Vs. Manufacturing



SOURCE: Bureau of the Census, U.S. Department of Commerce.

The post-1974 growth in compensation per production worker hour continued until 1982, when it peaked at $23.78, according to the American Iron and Steel Institute. Thereafter, the precarious financial state of the iron and steel industry produced a more conciliatory labor bargaining stance; per hour compensation dropped to $22.21 in 1983, and to $21.30 in 1984 tack to the 1981 levels.

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In Addition to its Unprecedented Growth, Compensation Shifted From "Take Home Pay" to "Fringe Benefits"

These increases in compensation paid by the iron and steel industry were not reflected entirely in workers' paychecks; the distribution of total compensation between payroll and "fringes" changed markedly. In 1958 nine out of every ten dollars of labor compensation were paid directly to workers as payroll; by 1980 workers were paid directly less than seven and one-half of every ten dollars of total compensation.

The rise in importance of supplemental compensation partly reflects increases in legally-mandated employer costs, such as Social Security payments, Workmen's Compensation, and unemployment insurance; however, the lion's share of this growth was due to increases in programs voluntarily or contractually supplied by employers: insurance programs, private pension plans, and of lesser importance, supplemental unemployment benefit funds.

Supplements have more than doubled in importance as a proportion of total compensation since 1958. In the latter part of the 1970's this growth slowed, however: up to 1966, supplements were growing at an eleven percent annual rate, and between 1966 and 1974, at better than 12 percent yearly. But after 1974 growth slowed to less than ten percent per year. Supplements remained at roughly one of every five dollars paid to iron and steel workers in the 1974-80 period.

The table below, along with Figure 40, shows the relative shift in these elements over time:

TABLE 19

Percent Distribution Of Labor Compensation

Year	Compensation	Payroll	Total Supplements	Required	Voluntary
1958	100.0%	90.0%	10.0%	2.4%	7.6%
1966	100.0	85.7	14.3	4.5	9.8
1974	100.0	80.3	19.8	5.7	14.1
1980	100.0	76.7	23.3	6.4	16.9

SOURCE: Office of Business Analysis, U.S. Department of Commerce.

As might be expected, the trends in supplemental compensation differ among occupational classes within the industry. Non-wage compensation in general grew at a faster rate for production workers than for nonproduction workers, as the following table shows:

TABLE 20

Average Annual Growth In Supplemental Compensation

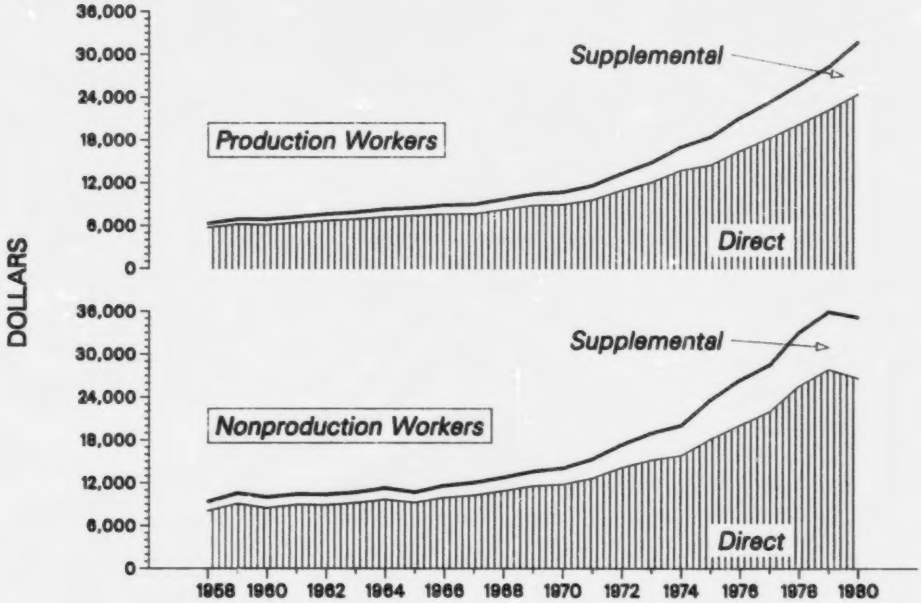
Period	Production Workers	Nonproduction Workers
1958-66	9.7%	2.5%
1966-74	11.7	12.2
1974-80	14.3	12.8

SOURCE: Office of Business Analysis, U.S. Department of Commerce.

By 1980, the proportions for production and nonproduction workers had reached the same level, at roughly 24 percent of total compensation.

FIGURE 40

Components Of Total Labor Compensation

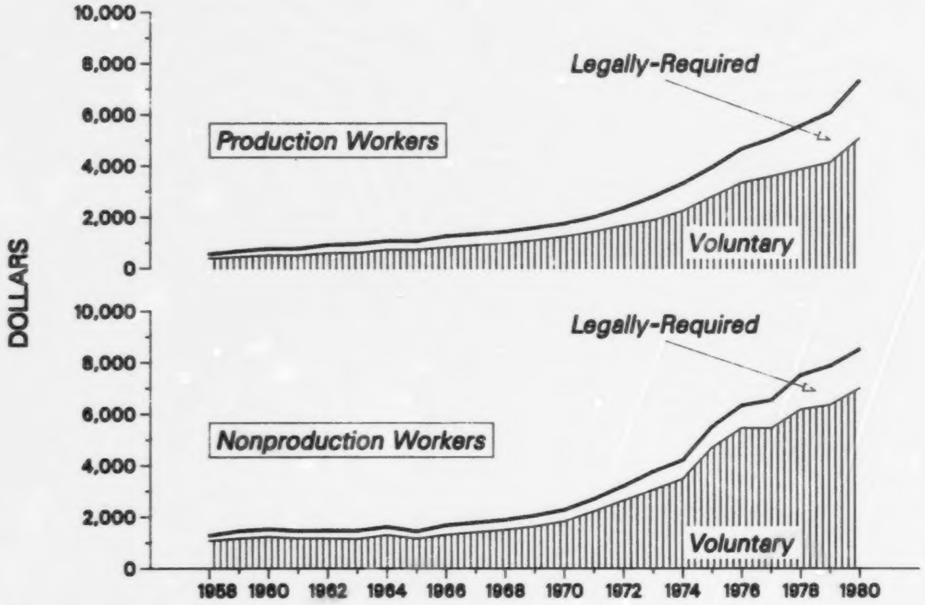


SOURCE: Bureau of the Census and Office of Business Analysis, U.S. Department of Commerce.

Figure 41, below, points to voluntary components as the source of much of the growth in supplemental compensation during the 1970's. For both production and nonproduction workers, the bulk of nonwage compensation growth came in the form of fringe benefits beyond those legally-mandated. For production workers, those voluntary supplements accounted for roughly 70 percent of supplements throughout the 1958-80 period. For nonproduction workers the proportion fluctuated between 80 and 85 percent during the interval.

FIGURE 41

Components Of Supplemental Compensation



SOURCE: Bureau of the Census and Office of Business Analysis, U.S. Department of Commerce.

What types of voluntary fringe benefits was the iron and steel industry supplying? Tables 21 and 22 show the trends for both types of workers.

Insurance plans have tended to be the largest benefit received by production workers; pension plans, fueled by the aging workforce and early retirement programs, had regained their earlier importance by 1980. The "Other" category includes employee savings plans and vacation and holiday funds; contributions to these components fluctuated widely over the interval.

Pension plans are uniformly a more important part of nonproduction workers fringe benefits than any other component. Unemployment funds are almost nonexistent, compared with their importance to production workers. The bulk of the "Other" category is accounted for by employer contributions to savings and thrift plans for nonproduction workers; stock ownership plans, for example, would appear under this category.

TABLE 21

Voluntary Supplements: Production Workers

Compensation type	1958	1966	1974	1980
Total	100.0%	100.0%	100.0%	100.0%
Life, Accident & Health Insurance	34.5	48.6	48.2	47.5
Private Pensions	53.6	36.2	44.3	47.5
Unemployment Benefit Funds	11.8	6.5	2.6	3.4
Other	0.1	8.7	4.9	1.6

SOURCE: Office of Business Analysis, U.S. Department of Commerce.

TABLE 22

Voluntary Supplements: Nonproduction Workers

Compensation type	1958	1966	1974	1980
Total	100.0%	100.0%	100.0%	100.0%
Life, Accident & Health Insurance	37.2	39.0	30.1	32.6
Private Pensions	50.9	50.0	60.4	58.0
Unemployment Benefit Funds	0.1	0.1	0.1	0.3
Other	11.8	10.9	9.4	9.1

SOURCE: Office of Business Analysis, U.S. Department of Commerce.

Summary

In summary, over the 1958 to 1984 period the iron and steel industry has experienced a drop in overall employment, and a reduction in the intensity of use of its production workforce. The drop in employment affected production workers more than nonproduction workers, as the industry came to rely increasingly on technical workers.

The demographic characteristics of the remaining workers changed dramatically over the period. The number of female workers nearly doubled between 1958 and 1980, though their jobs were predominantly in nonproduction occupations. High school educations became common among workers, and the number of workers with postgraduate experience tripled. There was a general shift toward a younger workforce, with the under-35 year-old segment experiencing the most growth; the proportion of workers over 45 years-old remained nearly constant. These shifts toward younger, more educated workers led to growth in the professional and technical occupational groups, and away from the unskilled laborer group.

As employment contracted and production declined, labor compensation in the iron and steel industry grew with few interruptions, particularly after 1971. Beginning in that year and boosted after 1973 by the Experimental Negotiating Agreements, unit labor costs rose by 1980 to triple their 1958 level. This growth was driven by increases in supplemental compensation, which grew faster than payroll compensation -- especially for production workers. In turn, this supplemental growth was fueled almost entirely by employer expenditures for voluntary supplements. Life, accident, and health insurance programs and private pension plans together comprised over 90 percent of voluntary supplements by 1980; they were equal in importance to production workers, but nonproduction workers received a greater share of benefits in contributions to Pension plans.

D. ENERGY AND MATERIALS INPUTS

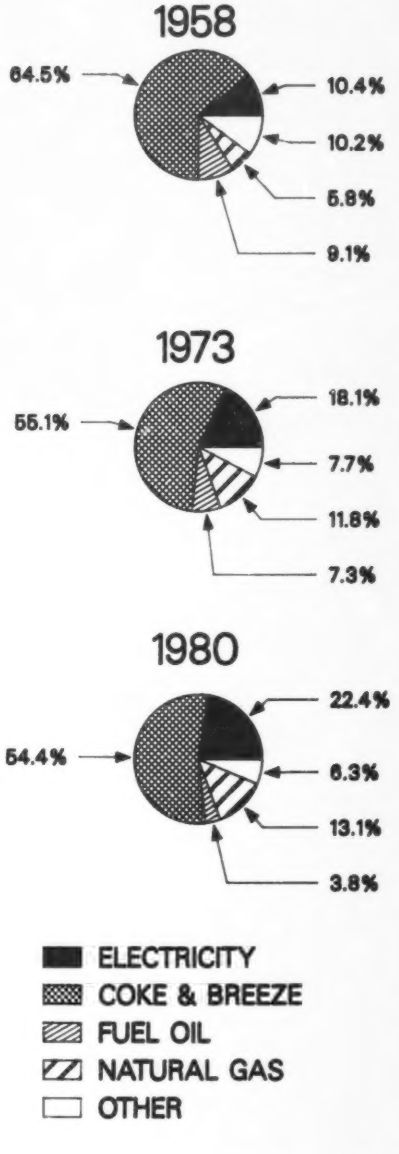
D.1 Energy Fuel Type Usage And Prices

Industry Fuel Switching Is Dictated By Technology Changes...

As the domestic steel industry has evolved from the open-hearth technology to the basic oxygen process and electric-arc technology, so has the energy fuel type required. Figure 42 describes the important changes that took place in the distribution of the industry's real (constant 1972 dollar) expenditures between 1958 and 1980. In 1958, when over 97 percent of steel was manufactured using the open-hearth technique, coke and breeze represented 64 percent of the industry's technical energy requirement. 1/ Electricity accounted for another 10 percent, while fuel oil accounted for nine percent. As the basic oxygen process and the electric-arc technologies rose in importance, the requirements for coke and breeze declined, and requirements for natural gas and electricity rose. By 1973, coke and breeze fell to only 55 percent of energy inputs while natural gas accounted for almost 12 percent and electricity 18 percent. The expanded use of

FIGURE 42

Total Energy Products Consumed
By Fuel Type
(Percent Based On Constant Dollars)



SOURCE: Office of Business Analysis, U.S. Department of Commerce

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1/ The Industrial Uses Accounts in the National Energy Accounts used here reflect end-demand energy input to the industrial production process. They do not reflect the primary energy input that was used to create electricity by the electric utilities industry but only the sale of electricity to an industry and the commensurate BTU's provided by the electricity. This type of accounting methodology has particular applications in the steel industry where part of SIC 3312, the coke oven products industry, purchases coal as an input to the product coke and its residue, breeze. Coke and breeze are classified as the primary end-demand energy input to the creation of iron and steel, not the original coal purchased by the 3-digit industry, SIC 331, Basic Iron and Steel.

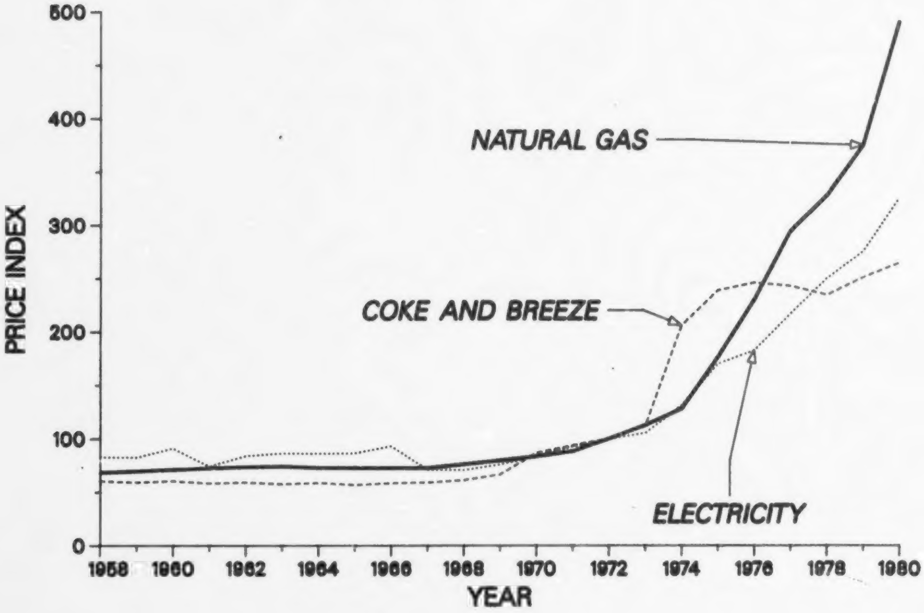
the electric-arc furnace in the 1958-73 period demanded a greater input of more refined iron ore. Other than scrap metal, this refined ore was made available through the beneficiation and pelletization process innovation. This process, which converts lower grade ores (called "taconite" ores) into refined ores suitable for both blast and electric-arc furnaces, uses natural gas to bake and harden the pellets before introducing them into the steelmaking furnaces. Another technological factor contributing to the increased use of natural gas during this time was that the industry started injecting "supplemental" fuels along with air into the blast furnaces in order to increase efficiency, improve furnace control, and decrease the consumption of coke. Natural gas was often used as the supplementary fuel. By 1980, these and other technology changes resulted in the industry consuming only 54 percent of its input in the form of coke and breeze; electricity jumped to 22 percent of energy inputs, but natural gas increased only slightly to 13 percent.

... And While Demand Soared For Electricity and Natural Gas, So Did Prices.

Figure 43 lists the price levels for the three most important energy inputs to the basic steel industries -- coke and breeze, electricity, and natural gas. Coke and breeze prices stayed relatively stable from 1958 through 1969, then rose an average of 15 percent per year through 1973. Prices almost doubled between 1973 and 1974, but they rose at the more moderate pace of less than 10 percent per year between 1974 and 1980. Electricity prices were relatively flat from 1958 through 1973, rising just over two percent per year. However, as a result of the hefty increase in the prices of primary fuels (including fuel

FIGURE 43

Selected Energy Input Price Indexes
(1972=100)



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

oil and coal) and the increased cost of pollution abatement equipment, electricity rates tripled from 1973 to 1980. Natural gas prices remained stable from 1958 through 1971, and rose moderately in 1972 and 1973. In 1973 a minimum price for new natural gas was set by the Federal Power Commission. This began a series of phased gas decontrol measures that drastically effected gas prices through 1980 and beyond. By 1980, the natural gas price index (1972=100) had skyrocketed to almost 500.

Since 1973, however, the steel industry's average energy input prices have remained somewhat lower than the U.S. manufacturing average, rising to an index of 324 compared with 350 in 1980. Because the industry was dependent on regional coal (which it often owned) as a primary energy input, and less dependent on fuel oil in 1973, it was in a relatively better position when the oil crisis occurred. The industry, however, found itself in a paradox. As the new efficient steelmaking technologies were slowly being brought on-line in the late 1970's, technologies that were gas and electricity intensive, prices for those two fuels were rising faster than prices of the fuel they were replacing: coal. The industry's fuel switching was technology--not price--driven.

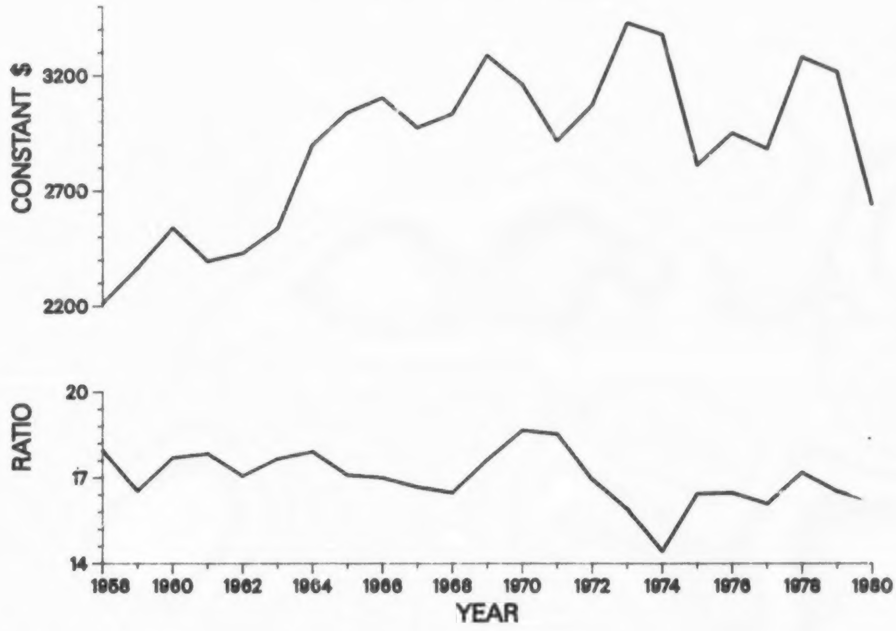
D.2. Energy Input Consumption Levels And Energy Efficiency

Inelastic Demand For Energy In An Energy Intensive Industry......

Major changes in steelmaking technologies between 1958 and 1973 made possible reduced levels of real energy input. On the whole, however, energy input price elasticity of the steel industry production function can be classified as inelastic. During the pre-

FIGURE 44

Consumption Of Energy Inputs (Millions Of 1972 Dollars)
And Energy As A Percent Of Total
Real Intermediate Consumption



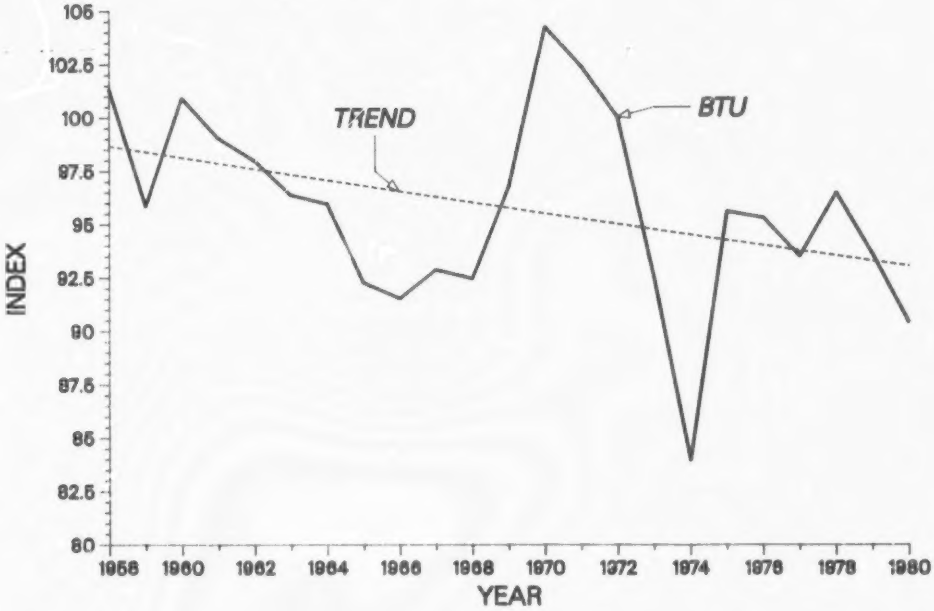
SOURCE: Office of Business Analysis, U.S. Department of Commerce.

Oil Embargo period, between 1972 and 1973, energy input prices rose almost 12 percent and the quantity consumed fell just over nine percent. In the post-1973 period, energy input prices almost doubled but energy consumption fell three percent.

The industry is one of the most energy intensive industries with an energy input cost share four times greater than the average U.S. manufacturing industry. Energy consumption, at $2.2 billion constant 1972 dollars, represented 18 percent of intermediate inputs to the industry in 1958 (see Figure 44). The energy share of real intermediate input remained fairly constant at around 17 and 18 percent until 1973. In 1974, the peak of industry output, energy inputs only accounted for 14.4 percent of constant dollar intermediate input, the all-time industry low. Since 1974, however, the industry has operated at persistently depressed levels of output and the share of energy in total real intermediate input has returned to more historic levels of around 17 percent.

FIGURE 45

Energy Efficiency Index
(BTU's Per Unit Of Constant Dollar Output)
(1972=100)



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

.... Where Efficiencies Are Related To Output Levels....

Energy efficiency improvements in the industry have been sporadic and minimal over the 1958-1980 period as can be seen in the industry's energy efficiency index and trendline in Figure 45. Here, the industry in 1972 used 107,000 BTU's per dollar of output and is indexed to 100. The index shows increasing energy efficiency through the 1958-1966 period reaching particularly impressive levels in 1965 and 1966, two high-output years. However, over the next four years, energy efficiency decreased. As output increased from 1970 to 1973, energy use per unit of output improved. By 1974, domestic steel production and capacity utilization reached all-time highs, helping energy efficiency reach the industry's most efficient point at 91,000 BTU's per dollar of constant dollar output. The 1975 through 1980 period shows a return to more long-run, historical trends as output levels fell.

.... And Industry Business Cycles.

This output/energy efficiency relationship can be further dramatized when energy efficiency levels are matched to business cycle fluctuations in the industry, ine Table 23.

TABLE 23

BTU's Per Dollar (1972 Dollars) Of Output

Year	Peak	Trough	Peak: Trough
1959[2]	103,000	--------	--------
1961	--------	107,000	+3.9%
1966	99,000	--------	-------
1967	--------	100,000	+1.0%
1969	104,000	--------	-------
1971	--------	110,000	+5.8%
1974	91,000	--------	-------
1975	--------	103,000	+13.2%
1979	101,000	--------	-------

SOURCE: Office of Business Analysis, U.S. Department of Commerce.

In all cases, an economic downturn has caused a concomitant rise in the number of BTU's used per dollar of output compared with a preceding economic peak. In the four cases seen above, the industry energy efficiency decreased an average of seven percent in the trough year compared with the previous peak. There is very little evidence of long-run peak-to-peak energy efficiency improvements over the entire 20-year period from 1959 to 1979. Rather, temporary efficiencies have occurred only in years of high industry output where temporary economies of scale were captured. These have primarily resulted from the amortization of energy used to continually charge furnaces whether the mill is producing or not. With higher output levels this "fixed" energy input component is spread among more units of output.

The industry has had the potential to realize energy efficiency improvements, but those savings can only come about through turnover in the steel industry's capital equipment; and especially its capital plant and structures. Because historically the energy bill has been relatively high in the industry, there has always been an inducement to purchase more energy efficient capital. Since 1973, in particular, the industry has had

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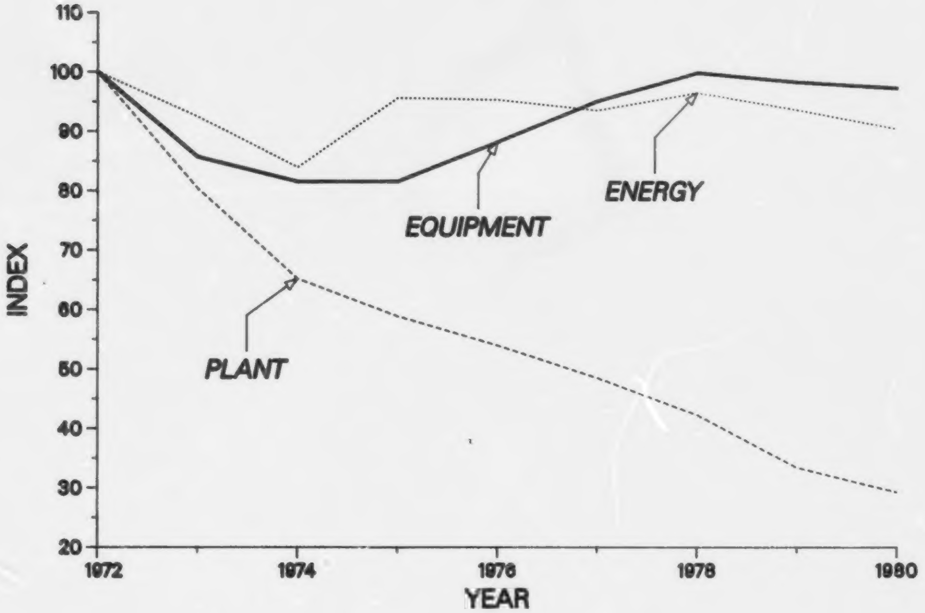
2/ While 1959 was not a peak output year, for most of the year the industry operated at a pace which far exceeded the pace in peak-year 1960. Despite the 119 day labor strike during 1959, 1959 constant dollar steel industry output was only two percent lower than 1960. In order to analyze energy efficiency properly, the 1959 production process and its relative efficiencies (while operating) have been chosen.

more cause to invest in more energy efficient capital. Figure 46 shows the valuation of industry plant and equipment less than five years old as a percent of all plant and equipment. This percentage has been indexed to 1972=100. In 1972, 32 percent of equipment was under five years old and 13 percent of plant and structures was under five years old.

The replacement of industry equipment has remained relatively steady over the 1972-80 period, however, the plant and structures turnover rate has declined remarkably. By 1980, only four percent of industry plant and structures had been purchased in the last five years, compared with a share of 20 percent in the late 1950's and early 1960's. Given this low level of turnover the industry has found it difficult to realize not only energy efficiency improvements but also overall productivity advancements.

FIGURE 46

Energy Efficiency And New Capital Indexes
(1972=100)



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

Summary

Primary iron and steel industry energy efficiency is directly and positively related to output levels (capacity utilization) and capital investment. From 1958 through 1966, both factors raised the industry's energy efficiency. In almost all years since 1966, output growth was stunted and capital investment stagnant, causing a lack of energy efficiency improvements. In addition, while the slow replacement of "old" technologies by "new" has allowed minor efficiency improvements, it came to the detriment of current energy cost accounts: the natural gas and electricity required by the new technologies were more expensive than the coal input they replaced.

D.3. Materials Inputs And Prices

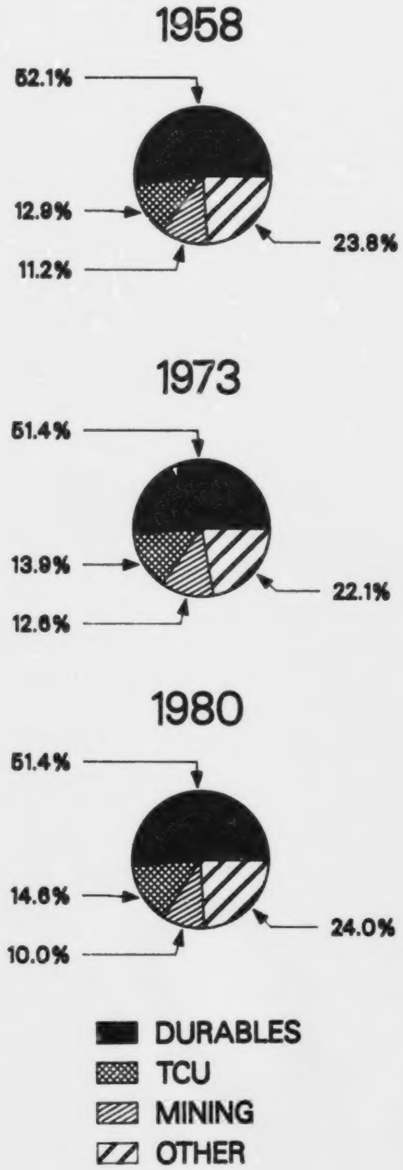
Industry Materials Inputs Change Minimally...

Materials inputs[3] to the primary iron and steel industry (SIC 331) include a large amount of purchases from within the industry itself. In 1958, just over 50 percent of industry non-energy constant dollar consumption came from the manufacturing durables sector, as shown in Figure 47, and almost 60 percent of that came from the blast furnace and steel mill industry (SIC 3312). This input represents a purchase of goods from one establishment by another, where both are in the same 3-digit SIC, but different 4-digit SIC's. In the steel industry, we generally see a transfer of blast furnace and steel mill output to establishments that produce more specific, shaped, and finished steel products. In addition to these intraindustry purchases in 1958, the transportation, communication, and utilities sector represented 13 percent of inputs; mining provided the third largest sectoral input at over 11 percent of intermediate non-energy inputs in 1958, almost all from the iron and ferroalloy ores mining industry.

The sector's material input shares have remained relatively constant over the 23-year period, with two minor exceptions. Iron and ferroalloy ores fell to 10 percent of non-energy inputs in 1980, from a higher level of almost 13 percent in 1973. As we will see this decrease was partially influenced by large price increases. Another, more subtle trend has been the movement away from intraindustry consumption. In 1958, 31 percent of industry purchases came from one of the four sub-industries within the primary iron and steel

FIGURE 47

Total Materials Inputs Consumed, By Sector (Percent Based On Constant Dollars)



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

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[3] The term materials is used throughout this report and, unless otherwise noted, includes all non-energy materials and services consumed by the industry.

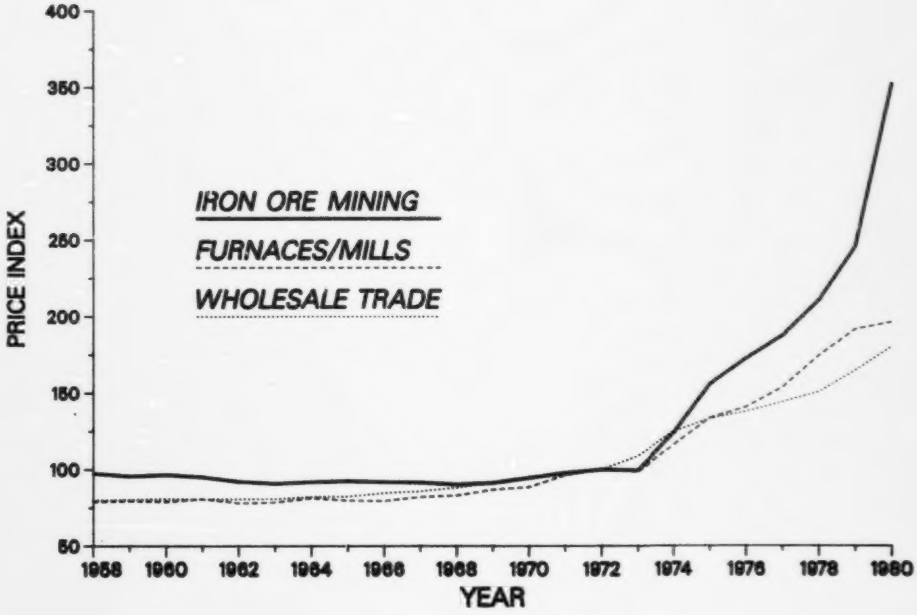
industry. This input from blast furnaces and steel mills decreased to 26 percent in 1973 and to 25 percent in 1980. Interestingly, this movement might be explained both by greater vertical integration (e.g., continuous processing) and by less vertical integration (e.g., mini-mills) within the industry. Both technologies result in more of the industry's product manufactured, formed, and finished within a single establishment. Materials, services, and energy efficiency improvements should all result from this structural change.

...And Iron Ore Prices Exert Strong Influence On Average Input Prices.

The three largest suppliers to the industry--blast furnace and steel mills, iron ore mining, and the wholesale trade industry--have experienced relatively divergent price increases of their output since 1958 (Figure 48). Because the blast furnace and steel mill industry is an integral part of the subject industry, its price movements very much parallel average primary iron and steel industry prices. Wholesale trade prices have historically risen at a very constant, moderate pace. In 17 of the 22 years the steel industry faced wholesale trade price increases of less than 4.5 percent, and only in one year (1974) did prices increase by more that 10 percent.

FIGURE 48

Major Materials Input Price Indexes
(1972=100)



SOURCE: Office of Business Analysis and Bureau of Economic Analysis, U.S. Department of Commerce.

Prices for iron ore mining inputs were very stable throughout the 1958 to 1973 period. During the entire 15-year period, the price level was never more than five percent higher or lower than the average price over the period. This stability ended in 1974, as prices for iron ore mining inputs rose over 25 percent due to excess world-wide demand. They continued to rise and averaged over nine percent a year until 1980, when the price index (1972=100) reached 353. This level is in stark contrast to the 1980 average materials input price index for all other materials inputs of 202, which was 16 points lower than the industry total price index. As mentioned in the earlier section, the high iron ore price increases led the industry to make downward adjustments in the share of iron ore inputs to the production process. Much of this movement involved the substitution of scrap iron and steel for iron ore and was made possible by the increased use of the basic oxygen process and the electric-arc technologies.

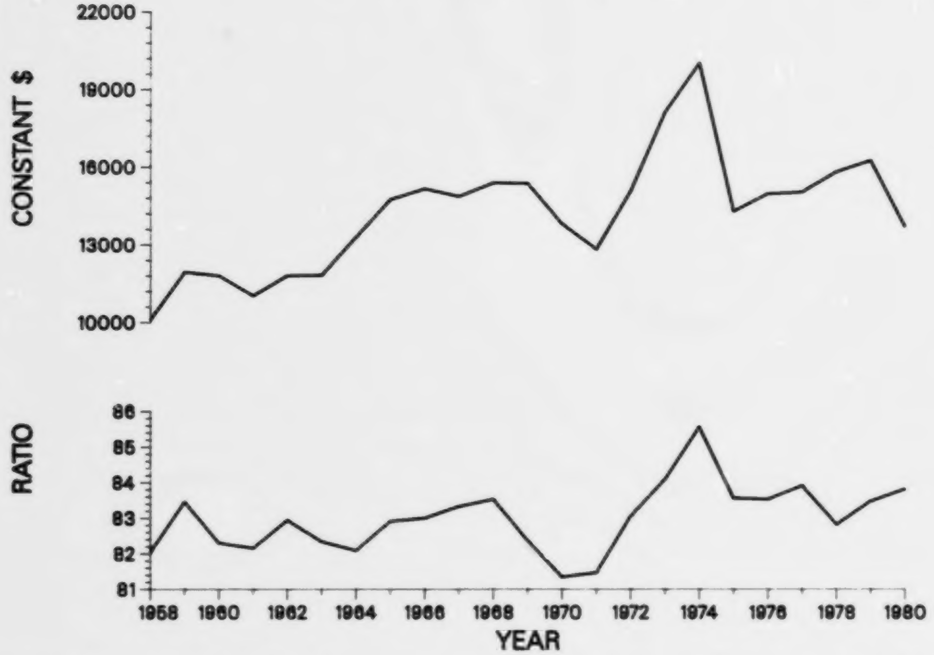
D.4. Materials Input Consumption Levels and Efficiency

Efficiency Improvements Have Not Been Realized....

Materials inputs into this relatively energy intensive industry stood at $10.1 billion in 1958 -- or 82 percent of the industry's total constant dollar intermediate inputs. (Figure 49). These non-energy inputs remained somewhat stable until 1972, when they began to account for a greater share of the industry's technological input structure compared with energy inputs. Material inputs peaked in 1974, the industry's peak output year, accounting for almost 86 percent of total intermediate inputs. From 1975 to 1980, constant dollar materials inputs remained at historically high input share levels of between 83 and 84 percent.

FIGURE 49

Constant Dollar Consumption Of Material Inputs
(Millions Of 1972 Dollars)
And Materials As A Percent Of Total
Real Intermediate Consumption

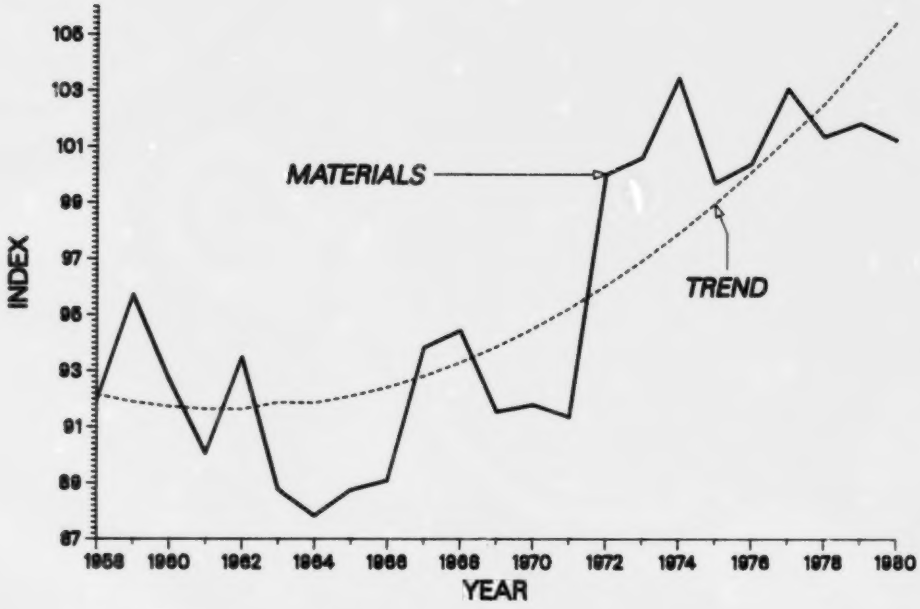


SOURCE: Office of Business Analysis and Bureau of Economic Analysis, U.S. Department of Commerce

These movements can also be seen in the industry's materials efficiency index shown in Figure 50. This index describes the growth in the efficiency with which the industry transforms materials inputs into output. A materials efficiency index has been calculated as the ratio of constant dollar non-energy inputs consumed, divided by constant dollar industry output. This annual relationship has been indexed to 1972=100. Figure 50 shows that since 1967 the index has trended in a unfavorable direction. The industry displayed slightly positive materials input efficiency from 1958 to 1966, but beginning in 1967 and through the next fourteen years, the industry began to consume greater amounts of materials inputs per dollar of output.

FIGURE 50

Materials Efficiency Index
(Constant Dollar Consumed Per Unit Of
Constant Dollar Output, 1972=100)



SOURCE: Office of Business Analysis and Bureau of Economic Analysis, U.S. Department of Commerce.

....Particularly During Business Peaks.

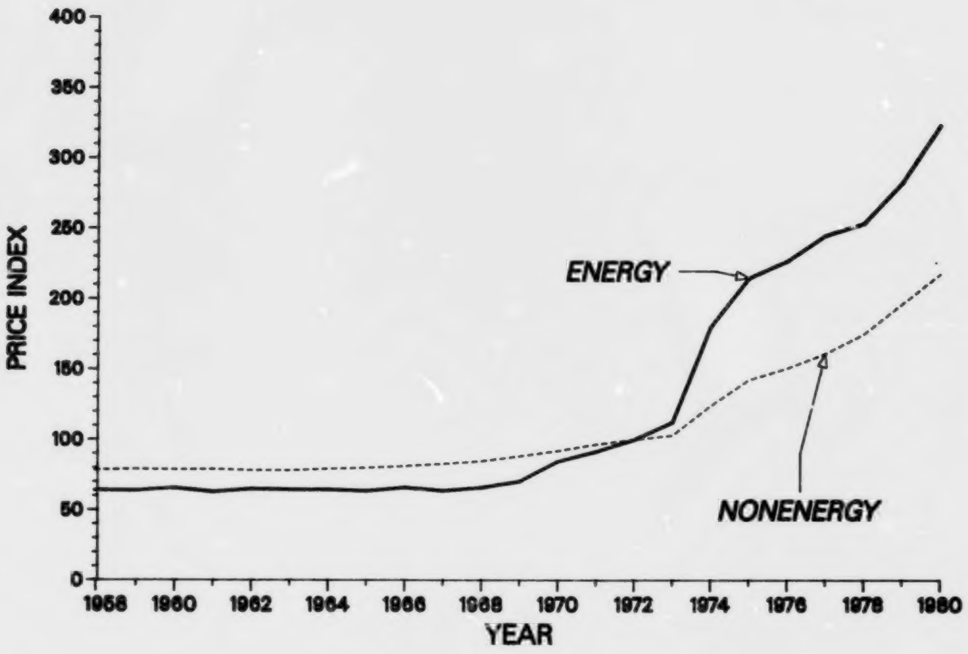
Demand for products from the primary iron and steel industry is highly cyclic. However, during steel industry business cycle peaks, there is very little evidence of materials efficiency improvements, particularly since 1969. It is apparent that, while major materials efficiency improvements have been realized by other U.S. manufacturing industries during business cycle peaks, the U.S. primary iron and steel industry was not able to capitalize on the opportunities as effectively. This was particularly true in 1973, 1974, and 1979, when high output, high capacity utilization, and industry business cycle peaks occurred, but the industry registered some of its worst materials efficiency levels. In contrast, U.S. manufacturing as a whole registered annual materials efficiency improvements in each of the three years averaging 2.6 percent.

D.5. Comparison Of Energy And Materials Prices

Energy price increases faced by the industry began to exceed materials price increases in 1970; the twelve years prior to 1970 show relatively stable prices for both types of intermediate inputs. More rapid energy price increases began in 1974 as the energy price index rose to an index of 324 by 1980 (1972=100) compared with the materials price index of 218 as seen in Figure 51. These price movements combined with the change in steelmaking technologies exerted strong influences on factor substitution not only between these two intermediate inputs but also among all inputs to steel production. These important substitution patterns are examined in detail in the following section F.

FIGURE 51

Intermediate Input Price Indexes
(1972=100)



SOURCE: Office of Business Analysis and Bureau of Economic Analysis, U.S. Department of Commerce.

Summary

The primary iron and steel industry experienced increased output growth between 1958 and 1966. Intermediate input prices remained stable and the industry realized consistent energy and materials input efficiency improvements over this period. However, except for 1973 and 1974, constant dollar output levels never exceeded the level registered in 1966, and the energy and materials input efficiencies levels generally deteriorated over the 1967-78 period.

In addition to these structural declines, the industry has also suffered from the effects of rapid inflation in its electricity, natural gas, and iron ore inputs. Ironically, the new technologies slowly introduced during the 1970's increased the industry's consumption of natural gas and electricity-- two energy fuel types that have experienced very high price increases since 1973. Prices for iron ore products also skyrocketed after 1973, increasing the industry's materials bill. These factors when combined with the slow overall turnover rate in the industry's capital stock and the lack of the significant efficiency improvements have increased the domestic industry's cost per unit of production.

E. INPUT SUBSTITUTION PATTERNS

Technological Innovations And Trends In Relative Input Prices Produce Important Changes In Input Structure, 1958-80

E.1 Patterns In Input Substitution

Some of the more important implications of the analyses in sections A through D are reflected in the input substitution patterns depicted below in Figures 52 through 55 and summarized in Table 24. The seven input ratios shown in the Figures are measured in terms of real units -- employment for labor and constant dollar values for capital, direct energy, and materials -- and are indexes based on 1958=100. Capital is defined as net plant and equipment less capital used primarily to control pollution. Direct energy is defined as energy inputs used directly for the production of heat, power, lighting, and transportation. In each Figure, the shaded area between the index=100 line and the graph line, highlights the change in actual relative input use (for example, the number of nonproduction workers used per production worker) compared to the proportion that existed in 1958. On the other hand, the dark, straight-line segment curve represents the trend curve in relative input usage between selected business cycle output peaks. The first segment of the trend curve in each graph defines the growth in relative input usage between the 1959 and 1966 output peaks; the second segment between the 1966 and 1974 peaks; and the third segment between the 1974 and 1979 peaks.[1] The trend curve thus

TABLE 24

Input Substitution Patterns, Between Selected Output Peaks
(Compound Annual Percent Change)

Input Ratio	Peak-To-Peak Interval 1959-66	1966-74	1974-79
Nonproduction Workers: Production Workers	0.19	1.95	-0.06
Fixed Depreciable Capital: Production Workers	0.16	1.07	0.62
Energy:Production Workers	2.57	1.99	1.31
Energy:Fixed Depreciable Capital	2.40	0.91	0.70
Materials:Production Workers a/	2.09	2.94	0.91
Materials:Fixed Depreciable Capitala/	1.93	1.45	0.68
Materials:Energy a/	-0.47	0.31	0.21

a/ Growth rates shown are for 1966-73 and 1973-79. See footnote 1 below.

SOURCE: Office of Business Analysis, U.S. Department of Commerce.

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[1] The industry's 1974 output peak was so abnormally high that using it to define the long-run trends in the use of materials relative to other inputs produces misleading results. For this reason, the trend lines in Figures 54 and 55 and the materials-related growth rates in columns (2) and (3) of Table 24 are defined on the input ratios prevailing in 1973.

removes the obscuring effects of business cycles and more clearly describes how the primary iron and steel industry's long-run input structure was evolving under conditions of full or high production. These long-run changes in input substitution are summarized in Table 24.

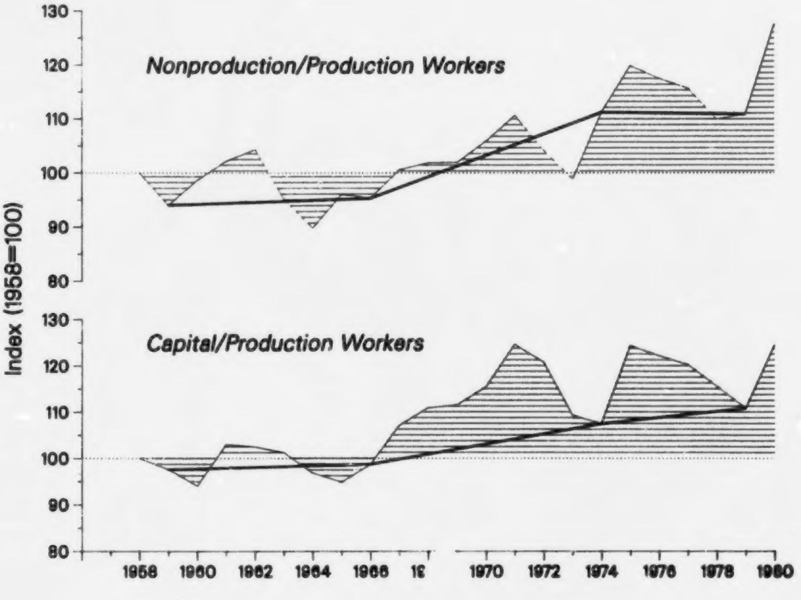
Perhaps the most important factor, underlying both the iron and steel industry's changing technology and input structure since 1958, has been the differential growth in the prices the industry paid to acquire each input type. Table 25 (page 116) shows the average annual growth in the prices the industry paid to acquire a unit of capital, labor, energy, and materials services during three peak-to-peak periods -- the pre-energy crisis subperiod, 1959-66; the first energy crisis subperiod, 1966-74; and the second energy crisis subperiod, 1974-79. When we compare the relative peak-to-peak input price growth patterns in Table 25 with the corresponding peak-to-peak input substitution patterns shown in Table 24, we would expect to see the industry substituting those inputs whose prices are growing more slowly for those whose prices are growing more rapidly. As we will see, this expectation corresponds closely to what actually transpired. An analysis of the factors which generated these long-run substitution patterns follows in section E.2.

Rapid Substitution Of NonProduction For Production Workers, 1966-74.

Figure 52 (top) shows the peak-to-peak trends in the industry's use of nonproduction workers relative to production workers. Except for cyclical variation during 1961-62, the ratio of nonproduction to production labor was constant during the 1959-66 interval. The index stood at 94 in 1959 and 95.3 in 1966. Between the 1966 and 1974 output peaks, however, the ratio of nonproduction to production workers grew at a

FIGURE 52

Input Substitution Patterns:
Ratios Of Nonproduction Workers And Capital To Production Workers
(Index, 1958=100)



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

compound annual rate of nearly 2.0 percent (Table 24), largely as a result of the industry's boom in production-labor-saving capital between 1964 and 1969. The 1974 capital:production worker index stood at 111.2, nearly 17 percent higher than in 1966. Thereafter, the ratio of nonproduction to production labor stabilized; with the 1979 index standing at 110.8, slightly below the 1974 value.

Slow Substitution Of Capital For Production Workers, 1959-79.

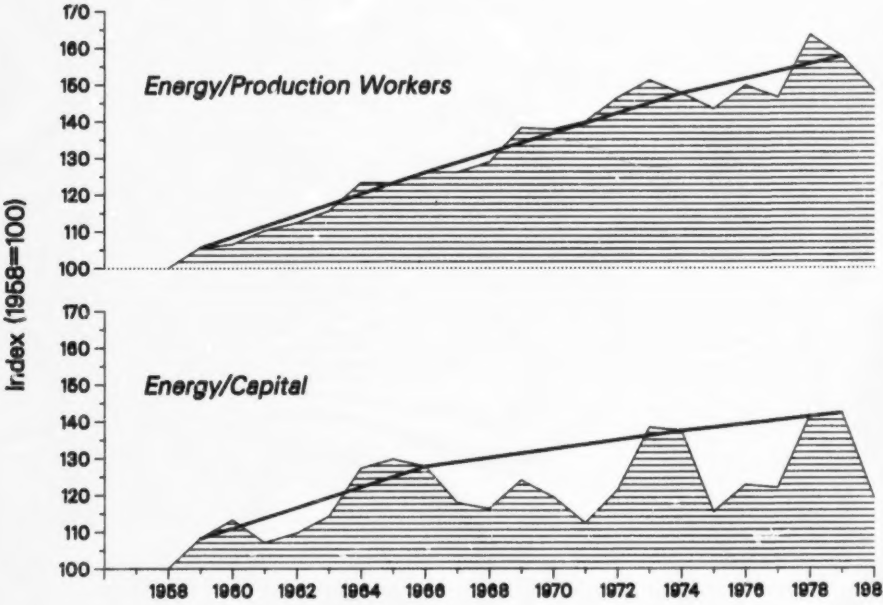
Figure 52 (bottom) describes the substitution of capital for production workers between 1958 and 1980. As was the case with nonproduction workers, the peak-to-peak, long-term trend curve shows that the industry did not substitute capital for production labor between the 1959 and 1966 output peaks. The capital:production worker index stood at 97.6 in 1959 and 98.7 in 1966. Between the 1966 and 1974 output peaks, however, the industry substituted capital for production workers at the compound annual rate of 1.1 percent (Table 24); so that the index rose to 107.4 in 1974, nearly 9.0 percent above its level in 1966. The industry continued to substitute capital for production labor between the 1974 and 1979 peaks, but at the compound rate of only 0.6 percent per year. By 1979, the index of real capital per production worker in the U.S. iron and steel industry stood at 110.8 -- 3.0 percent higher than in 1974.

Rapid Substitution Of Energy For Production Workers, 1959-79.

Figure 53 (top) demonstrates the growth in the substitution of real direct energy inputs for production workers. The index of energy to production labor increased by more than one-half between the 1959 and 1979 output peaks, as it grew persistently from

FIGURE 53

Input Substitution Patterns:
Ratios Of Direct Energy To Production Workers And To Capital
(Index, 1958=100)



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

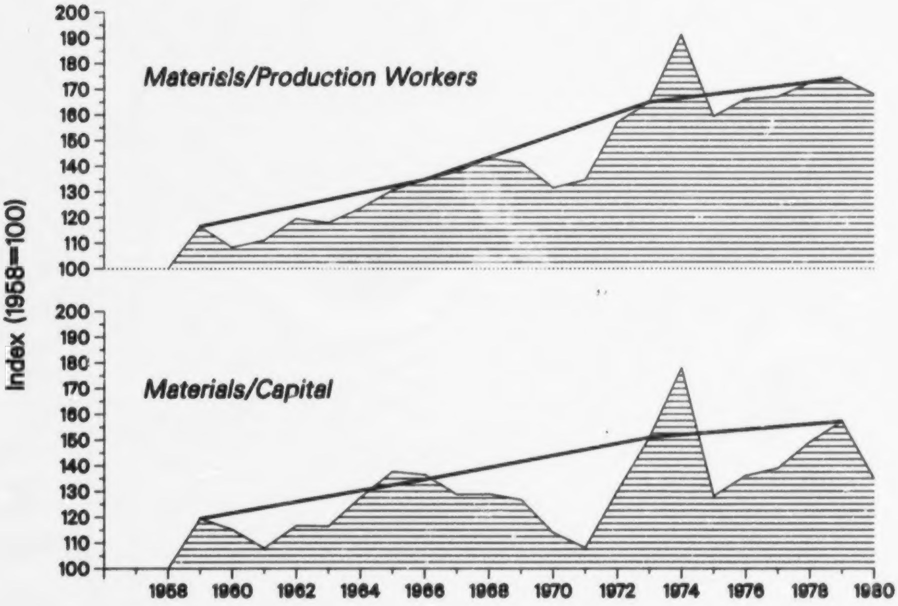
105.5 in 1959 to 157.5 in 1979. The trend curve shows, however, that the growth in this ratio was not uniform between output peaks. Between 1959 and 1966, real direct energy used per production worker increased at the compound rate of nearly 2.6 percent per year; it slowed to about 2.0 percent per year between the 1966 and 1974 peak years; but after the 1973-74 energy crisis, the peak-to-peak rate of growth declined to a compound annual rate of 1.3 percent between the 1974 and 1979 output peaks.

Substitution Of Energy For Capital Slows After 1966.

Figure 53 (bottom) illustrates the iron and steel industry's historical substitution of real direct energy for real capital. The peak-to-peak index of direct energy to capital rose nearly 32 percent, from 108.1 in 1959 to 142.2 in 1979. Between the 1959 and 1966 output peaks, the ratio of direct energy to capital advanced at the compound rate of 2.4 percent per year but at less than half that between 1966 and 1974 -- 0.9 percent per year. And after the 1973-74 energy crisis, the rate of substitution slowed further to just 0.7 percent per year between 1974 and 1979.

FIGURE 54

Input Substitution Patterns:
Ratios Of Materials To Production Workers And To Capital
(Index, 1958=100)



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

Materials Replace Production Workers And Capital At A Rapid Rate, 1959-74.

Figure 54 (top) demonstrates the change that took place in the iron and steel industry's materials:production worker ratio during the 1958-80 period. The industry's use of materials relative to production labor increased nearly 50 percent between the 1959 and 1979 peak-output years, with the index rising from 116.5 to 174.1 in 1979. The index of real materials per production worker grew at a compound annual rate of more than 2.0 percent between 1959 and 1966 but at a rate of almost 3.0 percent between 1966 and 1973. However, the rate of substitution declined to only 0.9 percent per year between 1973 and 1979.

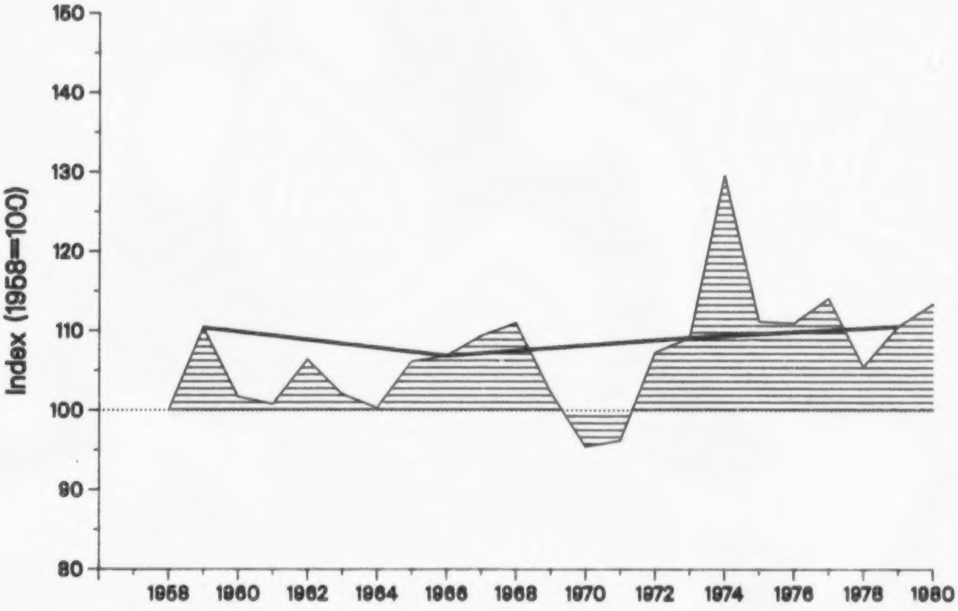
Figure 54 (bottom) shows the steel industry's substitution of real materials inputs for real capital inputs. The materials:capital ratio index stood at 119.4 in 1959 and at 157.2 in 1979, an increase of nearly 32 percent The substitution of materials for capital was most rapid between 1959 and 1966, when it advanced at the compound annual rate of nearly 2.0 percent (Table 24). The growth rate slowed to 1.45 percent per year between 1966 and 1973 but declined to less than 0.7 percent per annum between 1973 and 1979.

Slow Substitution Of Materials For Energy, 1966-79.

Finally, Figure 55 illustrates the historical evolution in the iron and steel industry's substitution of real materials inputs for real direct energy inputs. The materials:direct energy ratio index (1958=100) was virtually unchanged between the 1959 and 1979 peak-output years, standing at 110.4 in 1959 and 110.5 in 1979. The trend curve demonstrates that this constancy prevailed between each set of the three sets of peak-years. Between 1959 and 1966, the industry's use of materials inputs relative to energy inputs declined slightly at a compound annual rate of less than 0.5 percent (Table 24). Between 1966 and 1973, however, the industry substituted materials for energy but at the rate of only 0.3 percent per year. And after the 1973-74 energy crisis, the rate of materials for energy substitution fell to just 0.2 percent per year.

FIGURE 55

Input Substitution Patterns: Ratio Of Direct Energy To Materials a/
(Index, 1958=100)



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

E.2 Determinants Of Input Substitution Patterns

Low Capital Utilization Rates, and Cheap Energy And Materials Prices Govern Input Substitution During 1959-66...

Entering the decade of the sixties, the iron and steel industry found itself operating at relatively low rates of capacity utilization, ranging between 65 and 75 percent during the period 1958-61. Thus, the rapid 1962-66 expansion that followed the brief 1961 recession was initially accommodated by the industry through more intensive use of its in-place stock of plant and equipment, rather than through major capital modernization and expansion. Not until 1964 did the industry begin aggressively increasing its annual rate of investment; this investment episode peaked in 1967 but remained at high levels through 1969. Further, the industry's price of new capital during the 1959-66 peak-to-peak interval was growing at an average annual rate of 7.0 percent per year; faster than the prices of all other inputs (Table 25). Meanwhile, the prices of production and nonproduction labor were rising at moderate average annual rates of 3.6 and 1.4 percent per year, respectively. The prices of direct energy and materials inputs were also advancing, but at the very modest rates of 0.6 and 0.4 percent, respectively.

Given this set of economic conditions, the industry had little incentive during the 1959-66 period to greatly increase either its use of capital and nonproduction labor relative to production labor or its use of materials relative to energy. But, it had considerable incentive to increase its use of energy and materials relative to both capital and production labor. The factor substitution growth rates depicted in Table 24 and Figures 52 through 55 clearly reflect these considerations during the 1959-66 periods.

...But Relative Input Price Considerations Become Dominant During 1966-74...

During the next peak-to-peak interval, however, the unit prices of all inputs advanced at much higher rates (Table 25). Among noncapital inputs, the price of materials was increasing at the slowest average annual rate -- 5.3 percent -- and the price of production labor was rising faster than nonproduction labor -- 8.1 versus 6.8 percent. But energy prices were rising at an average annual rate of 13.0 percent -- faster than that of all other noncapital inputs. Moreover, the rate of peak-to-peak output growth declined by about two-thirds, from 4.4 percent during 1959-66 to just 1.6 percent during 1966-74. As a result, expanding economies of scale became a much less effective brake on the growth in unit production costs, making conservation in the use of rapidly inflating inputs and of inputs with large cost shares (such as production labor, energy, and materials) more important. During this time, the iron and steel industry thus aggressively substituted capital, nonproduction labor, and materials for production labor but substituted capital and materials for energy, as the industry sought to offset rapidly rising production labor and energy prices. It also increased the rate of substitution of capital for materials inputs (Table 24).

...And Double-Digit Growth In The Price of Labor And Declining Output Growth Governed Input Substitution Patterns During 1974-79.

Finally, during the 1974-79 interval, Table 25 show that the growth rates of new capital and direct energy prices deceased markedly, while the rate of price growth recorded by the two labor inputs and materials increased noticeably from their average annual 1966-74 rates. During this time, the real price of capital inputs inflated at a rate of just 5.7 percent per year -- slower than any other input, and the prices of production and nonproduction labor rose the fastest -- at average annual rates of 10.2 and 11.7 percent, respectively. Consistent with these relative input price movements, the industry substituted capital, energy, and materials for production labor, and greatly slowed the substitution of materials for capital (Table 24). However, the industry's depressed financial condition and its unfavorable growth prospects (the industry's average annual 1974-79 peak-to-peak output growth rate was a negative 3.8 percent) prevented it from substituting cost-saving capital at a more rapid rate.

TABLE 25

Comparison Of Growth Rates In Input Prices
During Selected Peak-To-Peak Intervals
(Average Annual Percent Change) a/

	Interval		
Input Type:	1959-66	1966-74	1974-79
Capital: b/			
New Capital Investment Price	1.5	4.8	8.9
Tax Offset	0.4	0.0	0.1
After-tax Investment Price	1.9	4.9	9.0
After-tax Real Gross Cost Of Capital	5.1	11.6	-3.3
Before Tax Adjustment Factor	0.0	0.0	0.0
Before-Tax Real Gross Cost Of Capital	5.1	11.6	-3.3
Before-Tax Price of Capital	7.0	16.5	5.7
Labor (Compensation/worker):			
Production workers	3.6	8.1	10.2
Nonproduction workers	1.4	6.8	11.7
Direct Energy	0.6	13.0	9.7
Materials	0.4	5.3	9.2

a/ b/ See notes to Table 25 at the end of this section.

SOURCE: Office of Business Analysis, U.S. Department of Commerce.

Differentials In Input Price Growth Helped Spur The Industry's Use Of Labor, Energy And Materials-Saving Technical Innovations.

One of the ways input price growth patterns produced more rapid cost saving input substitution after 1966, was by creating a stronger incentive for the iron and steel industry to accelerate the pace at which it was introducing cost-saving technical innovations. These innovations, which were described in detail in Part I:Section C and are summarized in Table 26, were generally capital embodied, and capital, labor, energy and materials-saving. On the whole, they reduced the demand for blue-collar workers and increased the demand for technically trained personnel, including process control engineers, programmers, laboratory testers, and research and development specialists as well as managers, officials, proprietors, and salesworkers. Figure 52 (top) clearly reflects the result of this phenomenon.

The electric-arc furnace reduced the capital, labor, energy and materials inputs required per ton of steel output, because they eliminated the need for blast furnaces, coke ovens, soaking pits, and reheating furnaces, etc. Indeed, it is estimated that U.S. mini-mills, which use the electric-arc process exclusively, produce their mix of steel products with one-third less energy and at a capital cost per ton which is less than half that required by U.S. integrated mills. And, today mini-mills can produce a ton of finished steel product with as little as $60 of labor, compared with a minimum of $195 for an integrated mill. In effect, the electric-arc furnace substitutes electricity and scrap metal for labor, coal, natural gas, and iron ore and substitutes capital for labor, energy, and materials. The growth in the capital:production worker ratio after 1966 recorded in Figure 52 (bottom) the growth in the materials:production worker and energy:production worker ratios between the 1959 and 1974 output peaks recorded in Figures 54 (top) and 53 (top); and the decline in the energy:capital and materials:capital ratios recorded in Figures 53 (bottom) and 54 (bottom) reflect the industry's increased use of the electric-arc technology.

This increased substitution of capital for the other inputs and of nonproduction for production workers in Figure 52 (top) also reflects the more widespread use of basic oxygen and continuous casting technologies as well as of larger blast furnaces and computers. The basic oxygen process, which has a smaller physical size but more capacity and uses one-fifth the labor of the open-hearth process, economizes on both capital and labor inputs per ton. On balance, however, this technology substitutes capital for labor. Continuous casting uses 10 to 15 percent less manpower, 15 to 20 percent less raw steel and 40 to 50 percent less energy than traditional ingot casting for the same amount of finished product. Larger blast furnaces require up to 50 percent fewer operations, fewer unskilled laborers, and about the same number of supervisors to produce a ton of iron as do conventionally sized blast furnaces. Finally, the installation of computers has led to a substantial savings of labor in hot strip mills.

The substitution of materials for energy shown in Figure 55 reflects the increase use of the electric-arc and basic oxygen processes. The basic oxygen process, because it uses 25 percent scrap and only 75 percent iron ore, substitutes materials for energy. Similarly, the electric-arc furnace, which can use 100 percent scrap, also substitutes materials for energy. Finally, part of the increased substitution of materials for energy in Figure 55 undoubtedly reflects the increase dependency of the U.S. iron and steel industry on inferior iron ore called taconite ores. These ores contain approximately 30 percent iron but they are subsequently refined into pellets containing 65 to 72 percent iron through the use of the beneficiation and pelletization process.

TABLE 26

Major Technical Innovations In The Steel Industry

TECHNOLOGY	DESCRIPTION	DIFFUSION
Beneficiation and pelletization	Improves quality and uniformity of iron ore for use in blast furnace; forms pellets of uniform high grade from rock of low iron content. Changes improve productivity and reduce operating costs.	Pellets accounted for 47 percent of ore consumed in 1973 and more than 70 percent in the early 1980's.
Direct reduction process	Processes ore into pellets of 90-95 percent iron content by treating with hot reducing gases; mostly used in electric-arc steelmaking furnace.	Three installations in operation in mid-1970's but one in 1985.
Basic oxygen process (BOP)	Steelmaking process using about 75 percent molten iron and 25 percent scrap in which oxygen is injected directly onto the iron, increasing the rate of reaction; 45 minutes to process a heat (the furnace capacity) compared with 9-10 hours for older open-hearth process. Requires roughly one-fifth the labor.	Accounted for 55 percent of production in 1973, 61 percent in 1981, and an expected 62 percent in 1985.
Electric-arc furnace	Steelmaking process using 100 percent scrap or other solid-state iron; requires one-half less capital, one-third the energy and uses less materials than for the conventional blast furnace/oxygen furnace. Eliminates the need for blast furnace, coking ovens, soaking pits, and reheating furnaces, etc.	Accounted for about 18 percent of production in 1973, 28 percent in 1981, and an expected 32 percent in 1985.
Continuous casting	Steel is poured directly from furnace ladle into the caster from which is emerges a semifinished slab, billet, or bloom; requries 10-15 percent less manpower, 15 to 20 percent less raw steel, and 40 to 50 percent less energy than traditional ingot method for the same output of finished steel by eliminating ingots and subsequent processes.	Accounted for less than 10 percent of steel produced in 1973 and 20 percent in 1984; expected to reach 40 percent in 1985.
Computer controls	Controls operations automatically; manpower requirements not significantly affected.	Less than 10 percent of all steel operations in the mid-1970's; largest number in rolling mills. Nearly 100 percent penetration in 1985 and now extends to all phases of steelmaking.

SOURCE: **Technological Change And Manpower Trends In Five Industries**, U.S. Department of Labor; Bureau of Labor Statistics, Bulletin 1856, 1975, p.22; and Office of Business Analysis, U.S. Department of Commerce.

Notes to Table 25

a/ All input price growth measures in the Table are appropriately based on before-tax input prices. The average annual percent change values shown here were computed by the method described in footnote 5 of PART III.

b/ The before-tax price of capital (P_k) is defined as:

$$P_k = q_k(1-uz-k)((r-w+d)/(1-u))$$

where q_k = the investment price of new plant and equipment and capital to the iron and steel industry; u = the industry's expected marginal corporate income tax rate on profits earned by the new capital at the point of investment; z = the present value of the depreciation the industry expects to take for tax purposes over the tax service life of the new capital; k = the industry's effective investment tax credit rate taken over its combined plant and equipment investment, after adjusting for tax credit carryforwards and carrybacks, etc.; r = the composite after-tax cost of capital from all sources used to finance the investment; w = the rate at which the industry expects to increase its product prices over the planning horizon and represents the industry ability to pay its future capital costs in cheaper dollars; and d = the expected rate of economic depreciation and represents the loss in asset value due to wear and tear and obsolescence over the economic service life of the newly acquired capital.

The price of capital can be decomposed into the product of two parts:

(1) the after-tax investment price, $q_k(1-uz-k)$, and

(2) the real before-tax gross cost of capital, $(r-w+d)/(1-u)$.

From this it follows that the growth in the before-tax price of capital consists of:

(1) the growth in the after-tax investment price of capital plus (2) the growth in the real before-tax gross cost of capital.

Part (1) is derived in the first three lines under the price of capital; part (2) is derived in the next three lines; and the resulting growth in the before - tax price of capital is given on line seven of Table 25.

The OBA estimated effective investment tax credit rates on equipment investment for the iron and steel industry were 0 in 1959, 6.2 percent in 1966, 6.7 percent in 1974, and 9.3 percent in 1979. The 1959, 1966, 1974, and 1979 expected corporate tax rates were 52, 48, 48 and 46 percent respectively. The present value of depreciation was set at 73.9 cents on a dollar in 1959, 74.5 cents in 1966, 68.8 cents in 1974, and 67.9 cents in 1979. These present value estimates were taken from Jorgenson and Sullivan; "Inflation and Corporate Capital Recovery," in C. Hulten (ed.) Depreciation, Inflation, and Taxation of Income from Capital, The Urban Institute, 1981. r is the composite cost of capital from Part II: Section B.3; w is estimated as a centered 5-year moving average of the percent changes in the industry's annual output price deflator; d is set at .04 for buildings and .12 for equipment and the overall d is obtained as a weighted average of the two economic depreciation rates, with the weights representing the historical dollar shares of plant and equipment in each year's total investment; and q_k is the industry's annual investment price deflator.

PART III

PRICES, PRODUCTIVITY, AND COSTS OF PRODUCTION SINCE 1958

INTRODUCTION

From Riches To Rags: How It Happened

PARTS I and II analyzed the important changes which have taken place in the production technology of U.S. iron and steel industry's and in its use of capital, labor, energy, and material inputs, and in the prices paid for these inputs. PART III synthesizes these changes into a comprehensive but nontechnical analysis of the evolution of output prices, productivity, and production costs in iron and steel manufacturing during the period 1958-80. This analysis more clearly defines and quantifies the important factors -- both those internal to the production process as well as market power factors -- which have determined the industry's current state of economic vitality and competitiveness.

The presentation proceeds as follows. Section A provides a simple explanation of the linkage between competitiveness and the growth patterns in input productivity, input price, and unit total cost of production. A cost-growth accounting framework is developed and then used in Section B to trace the sources of growth in the motor vehicles industry's non-capital unit cost of production back to the separate contributions of labor, energy, and materials.

Section B analyzes the iron and steel industry's historical performance with respect to:

- the relationship between its market power, unit output prices, unit total costs and rates of return to capital and labor relative to that in other selected U.S. manufacturing industries;
- the productivity growth obtained from its inputs -- both total factor and single factor productivity -- relative to that achieved in other selected U.S. manufacturing industries;
- the relationship of its input-specific unit costs of production to input-specific productivity and price experiences;
- the contribution made to the growth in its non-capital unit total cost of production by each of three broadly-defined, non-capital inputs -- labor, energy, and materials -- to its production process; and
- the performance of the iron and steel industry in controlling its total input and individual input production costs, compared with the performances of other selected U.S. manufacturing industries.

The data, facts, and analyses presented in PART III should be of special interest to those seeking to understand and evaluate the factors which have contributed to the apparent deterioration in the industry's production efficiency and competitiveness since 1973. Although the depth and breadth of the deterioration of the U.S. steel industry first became dramatically apparent during the late seventies, the ensuing analysis will demonstrate that the industry's decline is traceable to critical imbalances that were becoming obvious as far back as the mid-sixties and which, except for a brief respite in 1973-74, grew steadily worse.

A. ECONOMIC COMPETITIVENESS AND THE COST OF PRODUCTION

In recent years, the economic vitality of several formerly secure U.S. industries has been placed in jeopardy by either an actual or potential inability to compete in the market place. For example, in the aftermath of both the 1973-74 and the 1979-80 energy price shocks and the concomitant rapid growth in Japanese imports, there has been increasing concern about the survival of several historically powerful U.S. manufacturing industries, e.g., iron and steel and motor vehicles and parts.

As a result, of such events we often hear that U.S. industries must achieve higher productivity growth if they are to maintain their competitive position in the world-market environment. But, what is meant by this prescription is not well understood. Most Americans interpret it to mean that labor productivity must increase; when, in fact, improving the productivity growth of some other input may be more critical to the survival of a given industry. For example, we shall soon see that productivity growth in the use of materials inputs is nearly two times more important than labor productivity growth to the competitiveness of the U.S. iron and steel industry.1/

A more fundamental problem, though, is that productivity growth is only part of of the more complete measure of an industry's ability to compete. The more correct and inclusive standard for judging both an industry's productive efficiency and its competitive potential is its unit total cost of production over time. In the final analysis, this is what determines its "affordable" output price.2/

Under reasonably competitive conditions, the price an industry charges for its product over time will closely mirror its unit total cost of production:

(1) **Unit Total Cost** = Unit Capital Cost + Unit Labor Cost + Unit Materials Cost

+ Unit Energy Cost.

Accordingly, the rate of inflation in the industry's price will reflect the growth in total input unit cost:

1/ In 1980, materials cost represented 48 percent of total costs in the iron and steel industry, while labor costs represented only 26 percent. Thus, ceteris paribus, a 10 percent increase in materials productivity would produce a 4.8 percent decrease in the unit total cost of production, while the same increase in labor productivity would produce only a 2.6 percent reduction. See text above and formula (2) for details.

2/ The factors underlying an industry' unit cost of production can be termed the "supply-side" determinants of output price. Depending on the industry, many "demand-side" factors also affect the ability to compete -- the quality of the product, the technology embodied in it, the availability of substitutes, changes in exchange rates, and consumer tastes, and market (i.e. monopoly) pricing power etc. However, over time the dominant factor will ultimately be the price at which the industry can afford to sell its product, relative to the prices either of identical products produced by foreign competitors or of substitute products produced by both domestic and foreign competitors, and still remain in business. In turn, the industry's long-run "affordable" output price is determined by the unit cost it incurs to produce it. The analysis of the steel industry, which begins in section B, contains a discussion of both demand and supply factors which have been important determinants of the historical evolution of price determination in and the competitiveness of the U.S. motor vehicles and parts industry.

(2) **Growth in Unit Total Cost** =

$$\frac{\text{Capital Cost}}{\text{Total Input Cost}} \times (\text{Growth in Capital Price - Growth in Capital Productivity})$$

$$+$$

$$\frac{\text{Labor Cost}}{\text{Total Input Cost}} \times (\text{Growth in Labor Price - Growth in Labor Productivity})$$

$$+$$

$$\frac{\text{Energy Cost}}{\text{Total Input Cost}} \times (\text{Growth in Energy Price - Growth in Energy Productivity})$$

$$+$$

$$\frac{\text{Materials Cost}}{\text{Total Input Cost}} \times (\text{Growth in Materials Price - Growth in Materials Productivity}).$$

The four terms outside of the brackets in formula (2) are called the cost shares for each input and are obtained by dividing the cost for each input by the sum of the costs for all inputs. Moreover, the four bracketed terms in formula (2) represent the growth in unit capital costs, unit labor costs, unit energy costs, and unit materials costs.[3]

The cost-growth accounting formula (2) provides the framework needed to systematically define, measure, and examine the major **direct economic factors** underlying the historical evolution of an industry's cost structure. In simple terms, it demonstates that: **the growth in unit total cost of production is the composite result of twelve economic variables — the productivity growth in the four broadly defined inputs; the growth in the prices paid to acquire the services of these four inputs, and the relative importance of the cost of each input type to the total cost of all inputs.**

Thus, an industry can control or improve its unit total cost growth performance only if certain conditions are satisfied:

(1) either the productivity growth derived from each broadly defined input -- capital, labor, energy, and materials -- equals or exceeds the growth in the price paid for each input; or

(2) the cost-share weighted sum of the productivity growth derived from each input (total-input productivity growth) equals or exceeds the cost-share weighted sum of the growth in the prices paid for each input (total-input price growth).

In summary, productivity growth in isolation is only part of the competitiveness story. The more complete story requires a balance between input productivity growth and input price growth.

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[3] The actual method used in this study to calculate the growth rates and cost shares for formula (2) is described in footnote 5 below. It is also important to note that, while different in appearance, the total-input productivity growth derived from formula (2) and the measurement conventions of footnote 5 is formally equivalent to measures derived using the more conventional total-factor productivity formulas found in BLS and other economic publications and studies.

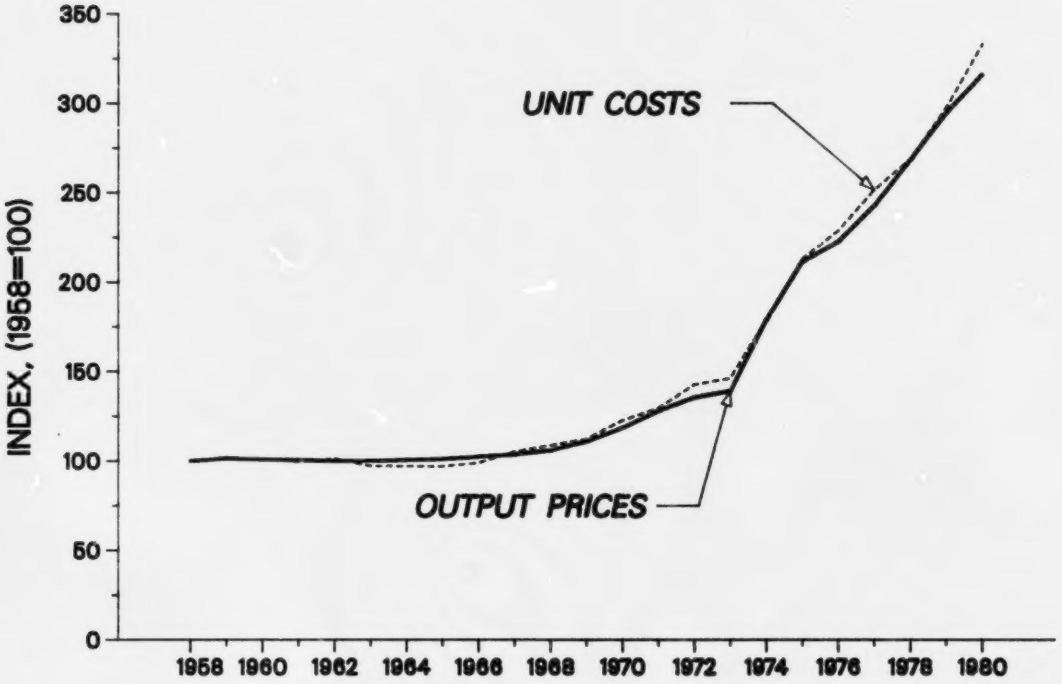
B. PRODUCTION EFFICIENCY AND THE ANATOMY OF PRODUCTION COSTS

Figures 56 through Figure 71 summarize the economic history (1958-80) of the U.S. primary iron and steel industry (SIC 331) in terms of real production, output prices, non-capital unit total costs of production 4/, input productivity, input prices, unit input costs, and the after-tax rate of return on capital.

B.1 Market Power, Unit Output Prices And Unit Total Cost

FIGURE 56

Output Prices And Non-Capital Unit Total Costs, 1958-80



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

Figure 56 demonstrates the very close historical relationship between output prices and non-capital unit total costs of production in SIC 331. This, coupled with the very similar output price and unit total cost growth rates shown in Figure 57, illustrates the extent to which price growth in steel is driven over time by the growth in its unit production costs.

4/ As of this writing, unit price of capital and unit cost of capital measures were not yet available (However, the price of capital and its several components are discussed in PART II: Section E). Accordingly, total unit costs of production in Figures 56 and 57 were computed ex-capital. However, the sum of labor, energy, and materials costs accounts for between 83 and 87 percent of the value of production.

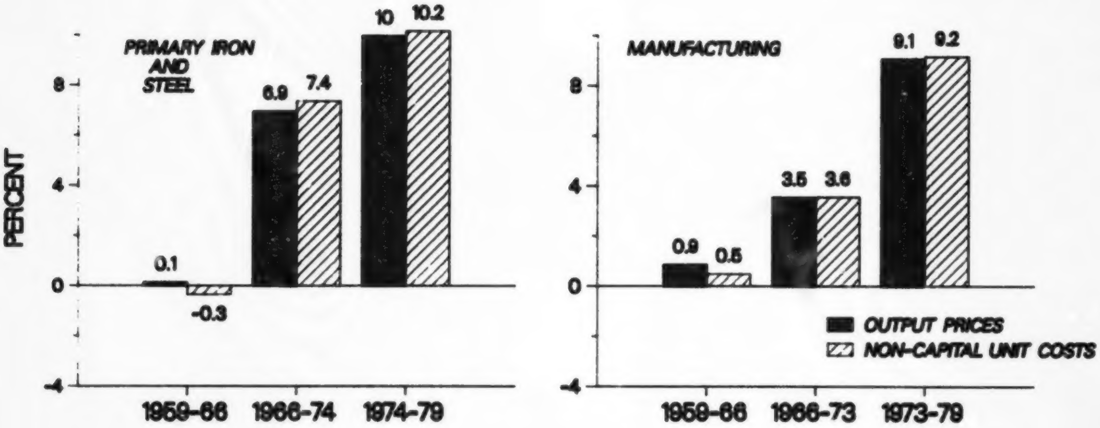
Unit Prices And Costs Virtually Unchanged 1958 To 1966; But Serious Imbalances Begin To Appear And Grow Thereafter...

Figure 57 shows that the unit output price index (1958=100) remained virtually unchanged between 1958 and 1966, with the index in 1966 standing at 102. After 1966, however, prices began a two-phase and uninterrupted climb, lasting through 1980. In the first phase (1966-73), the price index rose at an average annual rate of only 4.5 percent, with the 1973 index 39 percent higher than its 1958 and 1966 levels. This compares with 7.5 percent higher prices for manufacturing industries overall.

The 1958-73 historical profile of non-capital unit costs closely mirrored that of unit prices. Again, there was virtually no change in the level of unit costs between 1958 and 1966. The cost index in 1966 stood at 99 but it rose to 146 by 1973.

FIGURE 57

Inter-Industry Comparison Of The Growth In
Unit Output Prices And Noncapital Unit Total Costs,
Over Comparable Peak-To-Peak Intervals
(Average Annual Percent Changes)



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

Expressed in terms of average annual rates over peak-to-peak intervals, we find (Figure 57) that prices rose at an average rate of just 0.1 percent during 1959-66; but surged ahead at an average rate of 7.5 percent during 1966-74.5/ Similarly, unit cost declined at an average rate of 0.4 percent during the first interval but grew at an average rate of 7.4 percent during the second interval.

...But Escalate Sharply After 1973...

After 1973, unit output prices and unit costs entered a new era of double-digit growth rates. For example, prices and costs jumped an astonishing 28.7 and 22.3 percent respectively between 1973 and 1974. Furthermore, between the 1974 and 1979 peak output years, prices advanced at an average annual rate of 10.6 percent per year, while costs advanced at the average rate of 10.2 percent. By 1980 the price level was 216 percent above its 1958 level and 127 percent above its 1973 level (Figure 57). Similarly, excluding capital costs, the 1980 unit cost of production stood 233 percent above its 1958 level and 128 percent above its 1973 level. By comparison, the 1980 unit price and non-capital unit cost levels in overall manufacturing were 89 percent and 84 percent higher respectively than their 1973 levels.

Part Of A Manufacturing-Wide General Pattern; But Worse.

The radical change that took place after 1973 in unit output price and unit cost growth in SIC 331 was not unique. On the contrary, Figure 57 shows that a similar phenomenon occurred in U.S. manufacturing generally, following the energy price shocks of 1973-74 and 1979-80. True, among U.S. industries, steel is a relatively heavy consumer of energy related inputs but, as we shall see, energy prices explain only a small art of the industry's current troubled condition.

5/ The reader may notice that the percentage change measures presented here in PART III differ in some cases from those presented elsewhere in this report. This is because the method of calculation used here is different from the traditional calculation -- $((X_2 - X_1) / X_1) \times 100$. The calculation used here was: $(X_2 - X_1) / \frac{1}{2}(X_1 + X_2)$. This change was necessitated by the need to accommodate large changes in the variables included in the unit cost-growth accounting decomposition formula (2), which holds exactly only for small changes in the variables, around their initial values. In order that meaningful comparisons could be made between and among other percentage change values computed in PART III, all were computed by the same method.

Nevertheless, The U.S Iron and Steel Industry Was Able To Exercise Market Power To Gain Above Average Markups Over Costs...

Figure 58 compares the 1958-80 histories of the percentage markups over operating costs in the primary iron and steel, all-manufacturing, motor vehicles and parts, and plastics and synthetic materials industries. The markup rates shown for plastics and all-manufacturing represent pretax operating income divided by operating costs. The markup measures shown for steel and autos represent pretax operating income divided by operating costs after adjusting both measures to account for the premium over the all-manufacturing average annual rate of employee compensation paid to workers in iron and steel and autos.6/ The estimated compensation premium for each industry is then added to operating income and substracted from operating costs. The ratio of the adjusted income to costs provides a more comprehensive statement of the relative market power each industry has to set prices, earn profits, and pay wages in excess of those likely to be found under normal competitive conditions. The distribution

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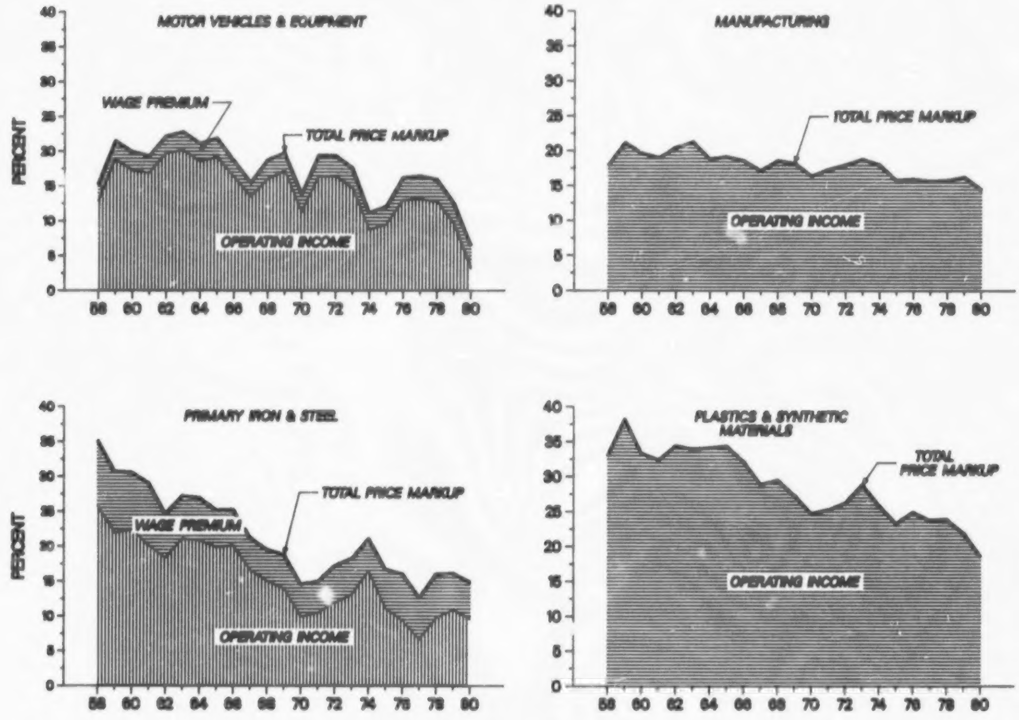
6/ The data used here are world-wide company income statement data from Standard & Poor's Compustat. Only companies whose primary SIC code was motor vehicles and parts or iron and steel, or plastics and synthetic materials were included. The employee compensation adjustment in steel and autos was made only to the steel or auto operations of the companies included in the steel or auto industry samples. The plastics industry compensation premium was set to zero, the estimated premium in steel was attributed to both production and nonproduction workers, and the estimated premium in autos was attributed only to production workers for the reasons discussed below. However, if the differential in average annual compensation per employee earned by workers in the plastic industry were treated as a premium derived from market power rather than from superior knowledge characteristics, the total markup rate would increase by less than two percentage points on average. The rationale and method underlying the estimated compensation premiums are as follows. First, industry average annual compensation rates above the all-manufacturing rate could stem from two sources: either higher levels of knowledge and experience or greater market power. Second, the measured compensation differential in each industry was assigned (in full or in part) to the latter category only when evidence on the knowledge characteristics embodied in the labor force of each industry did not indicate a clear superiority over those found in manufacturing industries generally. Several indicators of the knowledge characteristics of the production and nonproduction workforces (e.g., education, experience, and occupational demographic characteristics) in each industry were compared to those found in all-manufacturing (see Table 17 in PART II: Section C for an example of the types of labor quality indicators examined). This analysis indicated: (a) both production and nonproduction workers in plastics generally embodied substantially higher knowledge characteristics than their all-manufacturing counterparts; (b) both production and nonproduction workers in steel generally embodied knowledge characteristics that were lower or equal to those found in all-manufacturing; and (c) production workers in autos generally embodied knowledge characteristics that were only marginally superior to those in all-manufacturing (compared with a 40 to 70 percent average annual compensation differential), while those of nonproduction workers were also marginally superior with respect to most measures but substantially higher in one critical respect -- the proportion of nonproduction workers who are professional, technical or kindred workers. The nonproduction labor force in autos consistently contained 20 percent or more of such workers than did manufacturing industries generally. This embodied knowledge differential compares favorably with the 13 to 16 percent higher average annual compensation rates paid to nonproduction workers in the motor vehicles and parts industry.

over time of this normalized total markup to capital and labor income in the iron and steel and motor vehicles and parts industries is shown in Figure 58. It is clear from the Figure that the markup rate charged by all four industry groups underwent a persistent and pronounced decline since the early sixties. It is also clear that the markup rate in the steel industry was much larger than the all-manufacturing rate and even larger than the rate in motor vehicles and parts.

FIGURE 58

Inter-Industry Comparison Of Markup Rates
Over Normalized Operating Costs, Since 1958a/



a/ Markup Rate = (operating income before depreciation, interest and taxes + estimated labor compensation premium) divided by (cost of goods sold + selling & administrative expense - estimated labor compensation premium). Premium = 0 for plastics and all-manufacturing.

SOURCE: Standard & Poor's Compustat Services, Inc.; Trinet, Inc.; and Office of Business Analysis, U.S. Department of Commerce.

Table 27 summarizes the results of Figure 58 for the four industry groups. In particular it shows the average annual total markup over costs (expressed now as dollars of markup per $100 of production, selling and administrative costs) achieved by each industry during comparable peak-to-peak intervals. It also shows the distribution of the total markup between its estimated capital income and labor income components.

...But All Of Its Excess Goes To Labor...

Comparing the iron and steel data in column 2 with that of the other industry groups reveals that iron and steel charged consistently higher average markup rates than those charged by motor vehicles or manufacturing industries overall; but well below those charged by the plastics industry.

TABLE 27

Inter-Industry Comparison Of Average Annual
Markup Rates Over Normalized Operating Costs,
During Comparable Peak-To-Peak Intervals
(Dollars of Markup Per 100 Dollars of Cost)

	Peak-To-Peak Interval (1)	Total Markup (2)	=	Capital Income Markup (3)	+	Labor Income Markup (4)
Interval 1						
Motor Vehicles	1960-65	$21.20		$18.70		$2.50
Manufacturing	1959-66	20.10		20.10		0
Plastics & Synthetic Materials	1959-66	34.10		34.10		0
Iron & Steel	1959-66	27.40		20.60		6.80
Interval 2						
Motor Vehicles	1965-73	18.30		15.70		2.60
Manufacturing	1966-73	15.90		15.90		0
Plastics & Synthetic Materials	1966-74	27.60		27.60		0
Iron & Steel	1966-74	18.90		14.20		4.70
Interval 3						
Motor Vehicles	1973-78	14.90		12.00		2.90
Manufacturing	1973-79	12.80		12.80		0
Plastics & Synthetic Materials	1974-79	23.90		23.90		0
Iron & Steel	1974-79	16.40		10.70		5.70

SOURCE: Office of Business Analysis, U.S. Department of Commerce and Standard & Poor's Compustat Services, Inc.

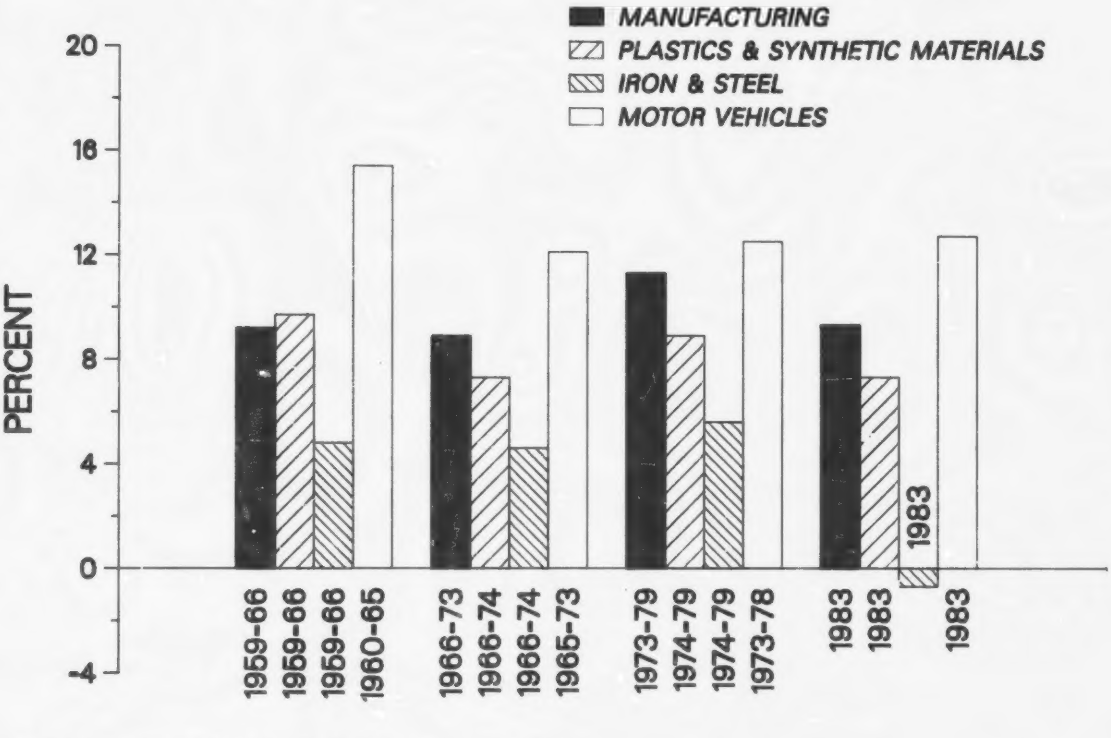
Column 4 of Table 27 implies that an estimated 25 to 35 cents (column 4 column 2) of each markup-dollar charged by the steel industry went for labor as opposed to capital income, compared with an estimated 12 to 19 cents in the motor vehicles industry. As a result, column 3 shows that the capital income markup rate in iron and steel has fallen from approximate parity with the all-manufacturing rate during the first interval to 12 percent less during the second interval ($14.20 versus $15.90), and to nearly 20 percent less ($10.70 versus $12.80) by the third interval. In addition, steel's capital income markup rate has gone from being greater than that earned by motor vehicles during the first interval ($20.60 versus $18.70) to being less during the second and third intervals.

...Yielding Well Below Average Returns To Capital...

Thus, when iron and steel capital income (including interest expense) is compared to its stock of fixed capital, Figure 59 demonstrates that it consistently earned after-taxes rates of return on invested capital much less than those earned by the all-manufacturing, autos, and plastics. For example, over its three consecutive peak-to-peak intervals, iron and steel earned 4.4, 4.6, and 5.6 percent, respectively, compared with only 9.2, 8.9, and 11.3 percent, respectively,for all-manufacturing and with 15.4, 12.1, and 12.5 percent for motor vehicles and parts. Moreover, in 1983, iron and steel experienced substantial losses, while motor vehicles earned 12.7 percent, and all-manufacturing earned 9.3 percent.

FIGURE 59

Inter-Industry Comparison of Average Annual After-tax Rates
Of Return on The Book Value Of Capital Stock,
Over Comparable Peak-To-Peak Intervals, And During 1983a/
(Average Annual Percent Changes)



a/ Return to capital includes interest expense.

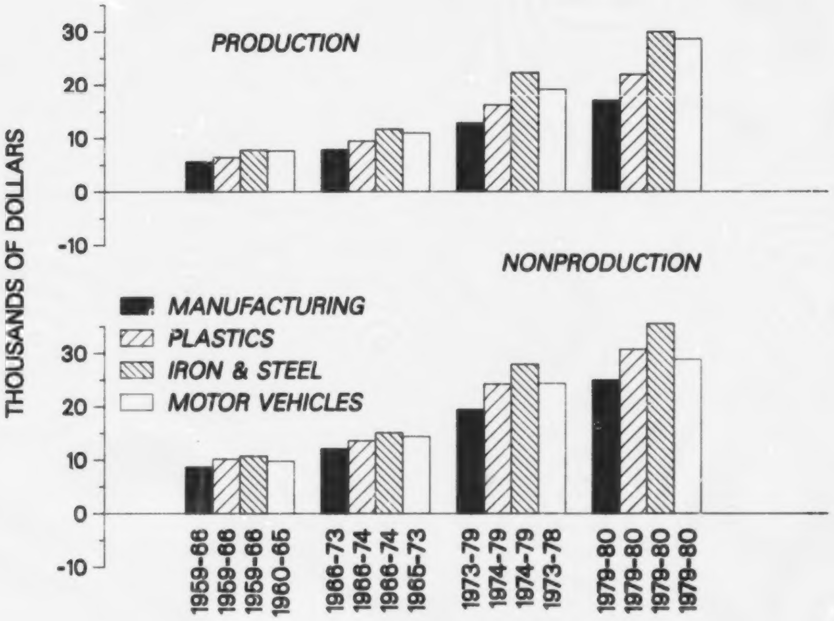
SOURCE: Standard & Poor's Compustat Services, Inc. and Office of Business Analysis, U.S. Department of Commerce.

...And Well Above Average Compensation To Labor; Particularly Production Labor...

Figure 60 shows that steel workers benefited handsomely from the fruits of the industry's market power; earning perhaps the highest annual rates of compensation in manufacturing. Steel's production workers were paid an average of $30,004 during the 1979-80 period, compared with $17,071 in all-manufacturing, $22,033 in plastics, and $28,692 in autos. During the first peak-to-peak interval, production workers in steel earned 40 percent more than their all-manufacturing counterparts and 21 percent more than workers in the highly productive plastics industry. However, over the next two sets of intervals shown in Figure 60, the gap with all-manufacturing grew to 74 percent. And by the 1979-80 interval, annual average compensation per production worker in steel was nearly 76 percent greater than the all-manufacturing rate, 4.6 percent greater than in autos, and more than 36 percent greater than the rate in plastics.

FIGURE 60

Inter-Industry Comparison Of Average Annual Compensation Rates
Paid To Production And Nonproduction Workers,
Over Comparable Peak-To-Peak Intervals, And During 1979-80



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

The industry's nonproduction workers have also continuously enjoyed better average annual compensation than their all-manufacturing peers. During 1979-80, nonproduction workers in steel earned 23 percent more than nonproduction workers in autos and 43 percent more than nonproduction workers in all-manufacturing -- an average annual compensation of $35,540, compared with $28,849 and $24,896, respectively. Although the percentage differential over all-manufacturing is small relative to that of production workers, it nevertheless increased sharply between the 1966-74 and 1974-79 peak-to-peak intervals. During the first peak-to-peak interval, for example, the percentage gap was 24.2 percent, 25.8 percent during 1966-74, but 44 percent during 1974-79.

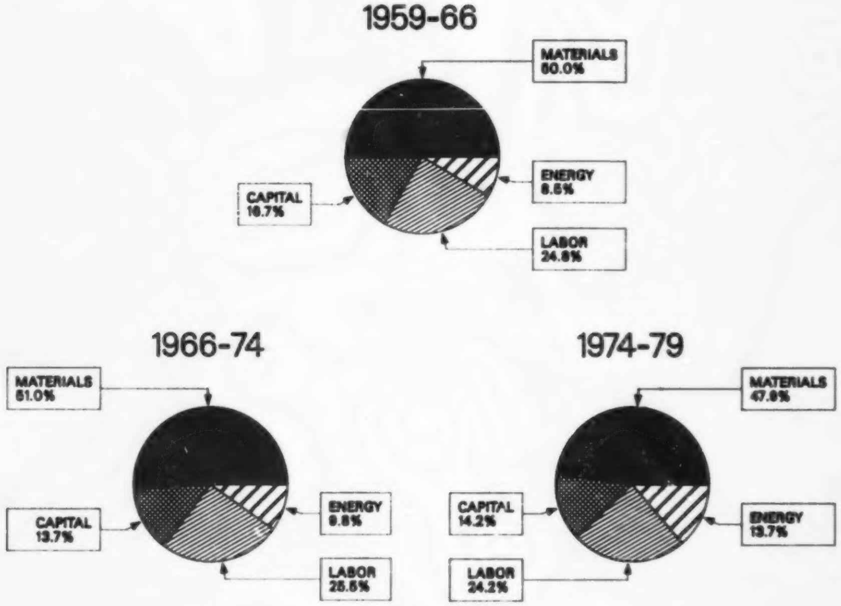
B.2 The Anatomy Of Unit Total-Input Production Costs

Revenue Shares: The Composition of Unit Price and Unit Cost...

Figure 61 describes how a dollar of revenue earned by steel was distributed in terms of average payments made to the four factors of production over major peak-to-peak intervals 7/. We see from Figure 61 that materials cost consumed on average about 50 percent of each sales dollar earned during 1959-74; declining to about 48 percent during 1974-79. Labor is the next biggest source of cost. It consumed on average about 25 percent of each revenue dollar between 1959 and 1974; and only slightly less (24 percent) between 1974 and 1979. However, labor's average share of total revenue was as high as 27 percent during 1970-72 and consumed more than 26 percent as recently as 1980.

FIGURE 61

Revenue Shares: Payments To Inputs As A Percent Of Current-Dollar Value Of Production: Peak-To-Peak Interval Percent Averages



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

Energy costs, meanwhile, consumed only between 8.5 and 10.0 percent of each dollar between 1959 and 1974. But, the average energy share jumped dramatically to almost 14 percent afterwards. Finally, Figure 61 demonstrates that the average share of revenue accruing to capital decreased after the 1959-66 interval. Capital's average

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7/ The input revenue shares shown in Figure 61 were computed as payments to capital, labor, energy, and materials relative to the current-dollar value of gross output produced by SIC 331. The payments to capital were computed as a residual -- current dollar output less payments to labor, energy, and materials.

revenue share was 16.7 percent during 1959-66, dropped to 13.7 percent in 1966-74, and rose slightly to 14.2 percent in 1974-79.[8]

Sources Of Growth In Unit Production Costs Since 1966...

The discussion of formula (2) in the previous section demonstrated that the growth in unit total cost of production could be traced directly to the growth in the unit cost associated with each of the four input classes -- capital, labor, energy, and materials. Here we apply a modified version of formula (2) to trace the sources of the average annual peak-to-peak growth in non-capital unit total costs back to the contribution made by the average annual growth in unit labor costs, unit energy costs, and unit materials costs.

TABLE 28

Inter-Industry Comparison Of Sources Of Growth
In Non-Capital Unit Costs Of Production,
Over Comparable Peak-To-Peak Intervals Since 1966

	----Input Contribution (average percent)----			
	Labor	Energy	Materials	Total
Interval 1				
Manufacturing (1966-73)	4.7	-0.7	96.0	100.0%
Plastics & synthetic materials (1966-74)	22.3	9.5	68.2	100.0%
Iron & steel (1966-74)	26.3	18.2	55.5	100.0%
Motor vehicles (1965-73)	51.0	2.1	46.9	100.0%
Interval 2				
Manufacturing (1973-79)	22.8	6.1	71.1	100.0%
Plastics & synthetic materials (1974-79)	7.6	3.8	88.6	100.0%
Iron & steel (1974-79)	31.6	17.4	51.0	100.0%
Motor vehicles (1973-78)	17.1	1.7	81.2	100.0%

SOURCE: Office of Business Analysis, U.S. Department of Commerce.

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[8] A note of caution concerning capital's value share is in order. Since capital's revenue share was computed as a residual, it may include several categories of expense which are traditionally not recognized as capital income, e.g., real estate taxes, sales taxes, excise taxes, etc.

Growth In Unit Total Costs Traced Primarily To Growth In Unit Labor And Unit Materials Costs...

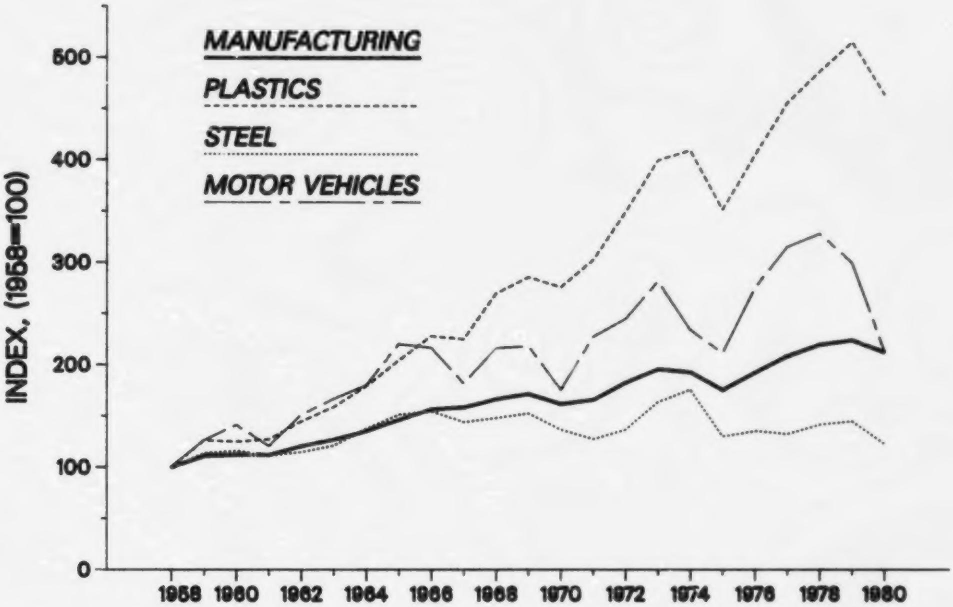
Table 28 summarizes the sources of growth in unit non-capital cost of production in steel and other U.S. manufacturing industries. We see there that only about 18 percent of the 1966-74 and 17 percent of the 1974-79 average annual growth rates in unit total costs in steel was due to the growth in unit direct energy costs. We also see that the growth in steel's unit labor costs accounted for about 26 percent of the 1966-74 average annual growth in unit total cost, but more than 31 percent of the 1974-79 growth; while the share accounted for by unit materials cost growth dropped from more than 55 percent to 51 percent. The contribution of the growth in unit labor costs to the growth in unit total costs in steel since 1973 substantially exceeds that found in other manufacturing industries.

To determine what lies behind these historical price and cost patterns, we turn to an examination of the three rate of growth measures -- input prices, input productivity, and unit input costs -- related to the four broad input classes -- capital, labor, energy, and materials -- delineated in formula (2) above. The historical information needed both to conduct this examination and to compare the produtive efficiency of SIC 331 with other selected U.S. manufacturing industries -- total manufacturing, plastics, and synthetic materials, and autos -- is found in the figures and tables which follow.

B. 3 Output Growth And Productivity Growth

FIGURE 62

Inter-Industry Comparison Of Constant-Dollar Output, 1958-80



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

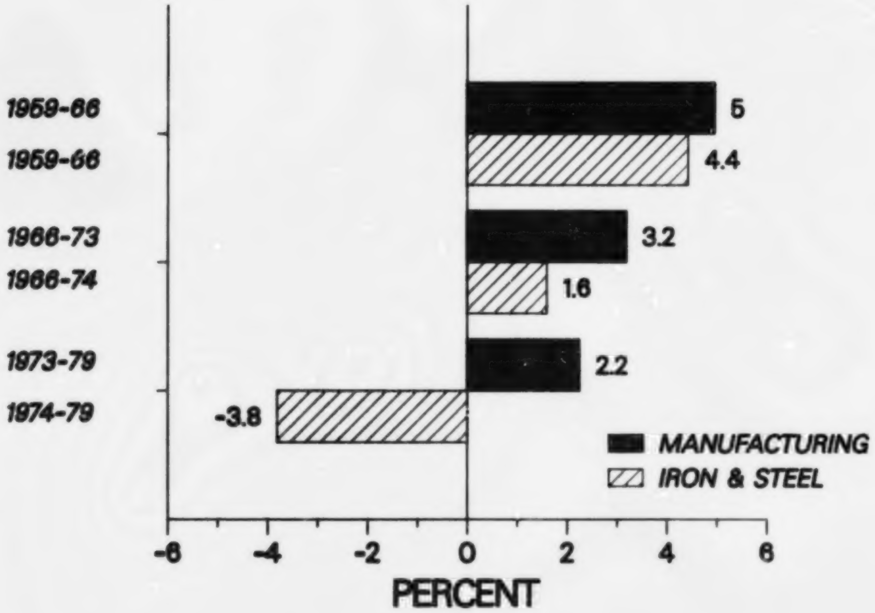
A Stagnant Industry: 1974 The Only Outstanding Year Since 1966...

Over the 1958-80 interval, real output (constant 1972 dollars) in the steel industry peaked in 1959, 1966, 1969, 1974, and 1979. However, Figure 62 clearly shows that, if the years 1973 and 1974 are excluded, each successive post-1966 output peak was lower than its previous peak value. Moreover, between the 1959 and 1979 output peaks, the level of real output grew only 27.9 percent -- from $24,083.8 million in 1959 to $30,800.3 million in 1979. This growth reciord is exceptionally poor among U.S. industries. For example, total manufacturing real output increased 124 percent between the 1959 and 1979 peaks, while the real output of the plastics and synthetic materials industry quadrupled between its 1959 and 1979 peaks. Another high flier, during the 1958-80 interval, was the auto industry. Its' output grew 132.6 percent between its 1960 and 1978 outputs peaks.

Presented in terms of average annual rates of growth over comparable peak-to-peak intervals, Figure 63 shows that real output in SIC 331 grew 4.4 percent in 1959-66; 1.6 percent in 1966-74; and -3.8 percent in 1974-79. This compares with comparable peak-to-peak average annual rates of 5.0, 3.2, and 2.3 percent for total manufacturing.

FIGURE 63

Inter-Industry Comparison Of Rates Of Growth
In Constant-Dollar Gross Output,
Over Comparable Peak-To-Peak Intervals
(Average Annual Percent Changes)



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

...And Low Output Growth Is A Major Contributor To Low Productivity Growth.

The very poor 1958-80 output growth performance in the steel industry appears to be an important factor in the industry's equally poor record in controlling unit output prices and costs. Evidence to this effect appears in Table 29.

We see that there are three important relationships between output growth and the productivity growth of each of the four broadly defined inputs. First, when peak-to-peak output growth declined significantly (e.g., after both 1966 and 1974 in the steel industry) input productivity growth, with few exceptions, did also. Second, this phenomenon holds not only for the steel industry but for total manufacturing, plastics, and autos as well. Third, during the second and third peak-to-peak intervals, the steel industry not only had lower rates of output growth than did the other industries but also, with few exceptions, it had correspondingly lower rates of input productivity growth.

...Average Total-Input Productivity Growth Fell Well Below The All-Manufacturing Rate And Had Become Increasingly Negative After 1966...

Finally, Table 29 shows that input between 1959 and 1966, total-input productivity growth in steel was significantly better than that recorded in all-manufacturing -- 1.8 versus 1.2 percent. However, between 1966 and 1974, steel's total-input input productivity declined at an average annual rate of 0.1 percent. During 1974-79, however, the rate of decline accelerated to 0.8 percent. Meanwhile, all-manufacturing recorded positive peak-to-peak total-input productivity growth -- 1.0 percent during 1966-73 and 0.6 during 1973-79.

TABLE 29

RELATIONSHIP BETWEEN INPUT PRODUCTIVITY AND REAL OUTPUT GROWTH
IN COMPARABLE PEAK-TO-PEAK INTERVALS
(AVERAGE OF ANNUAL PERCENT CHANGES)

INTERVAL 1

	ALL MANU-FACTURING	PLASTICS & SYNTHETIC MATERIALS	PRIMARY IRON & STEEL	MOTOR VEHICLES & EQUIPMENT
CONSTANT-DOLLAR OUTPUT	5.0	8.4	4.4	8.8
INPUT PRODUCTIVITY				
CAPITAL	2.0	1.5	2.9	6.5
LABOR	3.1	3.5	3.1	4.3
ENERGY	1.2	1.0	0.7	4.0
MATERIALS	0.1	1.3	1.0	1.1
TOTAL	1.2	1.7	1.8	2.1

INTERVAL 2

	ALL MANU-FACTURING	PLASTICS & SYNTHETIC MATERIALS	PRIMARY IRON & STEEL	MOTOR VEHICLES & EQUIPMENT
CONSTANT-DOLLAR OUTPUT	3.2	7.3	1.6	3.1
INPUT PRODUCTIVITY				
CAPITAL	-0.0	3.0	1.4	1.8
LABOR	2.7	6.2	2.1	2.2
ENERGY	0.9	2.6	1.1	1.7
MATERIALS	0.7	1.6	-1.9	1.4
TOTAL	1.0	2.7	-0.1	1.7

INTERVAL 3

	ALL MANU-FACTURING	PLASTICS & SYNTHETIC MATERIALS	PRIMARY IRON & STEEL	MOTOR VEHICLES & EQUIPMENT
CONSTANT-DOLLAR OUTPUT	2.3	4.6	-3.8	3.0
INPUT PRODUCTIVITY				
CAPITAL	-1.0	1.6	-2.1	1.7
LABOR	1.5	5.8	-1.5	2.3
ENERGY	1.8	6.3	-2.2	1.7
MATERIALS	0.8	0.1	0.3	-0.8
TOTAL	0.6	1.3	-0.8	0.1

PEAK-TO-PEAK intervals are defined as follows:

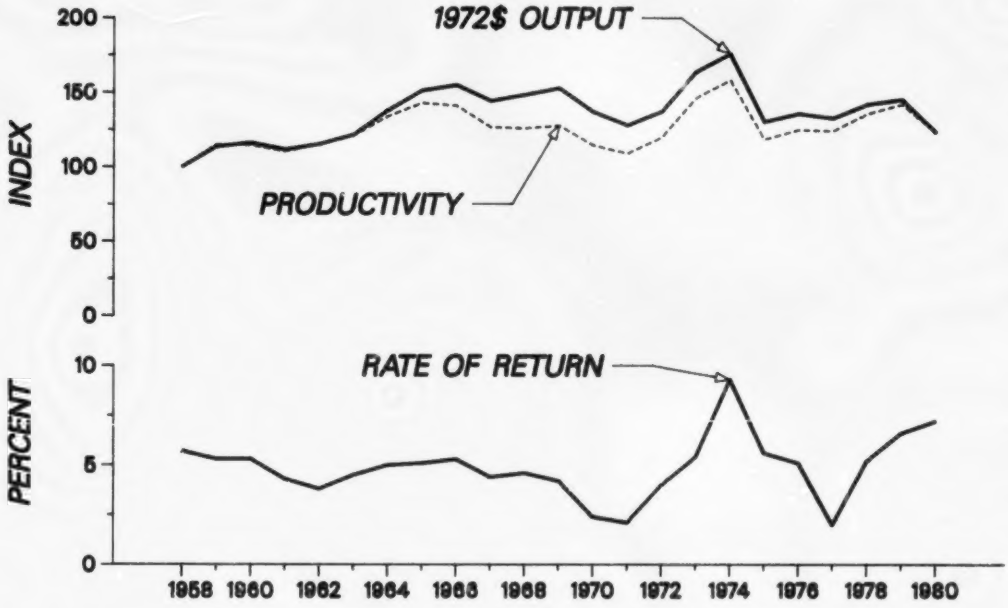
	Interval 1	Interval 2	Interval 3
MANUFACTURING	1959-66	1966-73	1973-79
PLASTICS	1959-66	1966-74	1974-79
IRON & STEEL	1959-66	1966-74	1974-79
MOTOR VEHICLES	1960-65	1965-73	1973-78

SOURCE: Office of Business Analysis, U.S. Department of Commerce.

B.4 Capital Productivity And The Rate Of Return To Capital

FIGURE 64

Output, Capital Productivity, And The After-Tax
Rate Of Return On Capital, 1958-80 a/



a/ Return to capital excludes interest expense.

SOURCE: Office of Business Analysis, U.S. Department of Commerce.

Figure 64 describes the historical profiles of capital productivity and the after-tax rate of return to capital. It also demonstrates that the profiles of both are strongly influenced by movements in real output. Both the cyclical patterns and trend among the three series are similar.

For example, the levels of capital productivity and the after-tax rate of return both peaked with output in 1966, 1974, and 1979. But more importantly, Figure 64 shows that, if the year 1974 is excluded, the trends in capital's productivity and its rate of return are, like that of output, clearly downward since 1966. Over the entire 1958-80 period, the highest capital productivity and rate of return levels were achieved in 1974. The 1974 level of capital productivity was 58 percent above its 1958 level; but only 12 percent higher than the levels achieved during the 1966 output peak. Moreover, relative to 1966, capital was no more productive in 1979. Meanwhile, the 1974 after-tax rate of return stood at 7.8 percent. This compares to other highs of 5.1 percent in 1958, 4.6 percent in 1966, and 5.0 percent in 1980.

Capital Productivity Growth Exceeds The All-Manufacturing Average 1959-74...

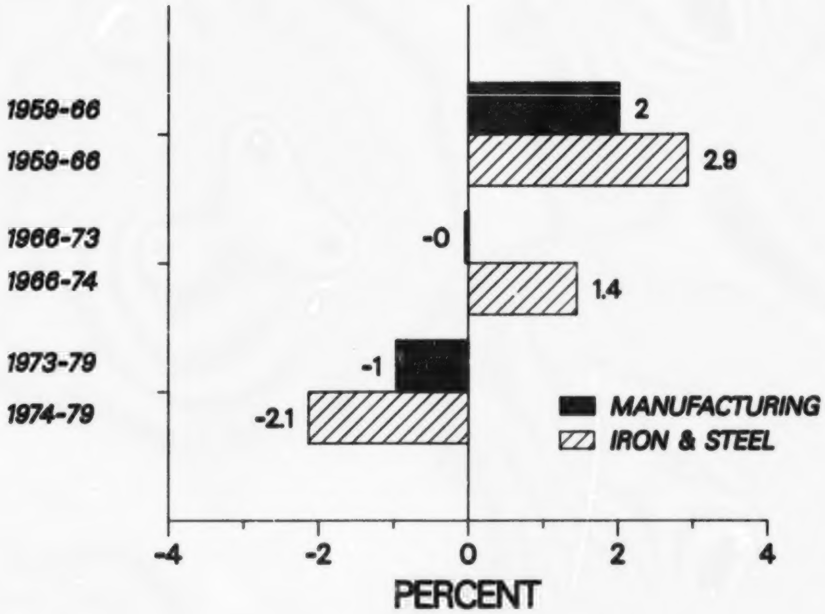
Figure 65 shows that, on a peak-to-peak basis, capital productivity advanced at an average annual rate of 2.9 percent per year between the 1959 and 1966 output peaks; but dropped by half to 1.4 percent between the 1966 and 1974 output peaks. Nevertheless, compared to total manufacturing (2.0 percent and 0.0 percent), we see that this was an above average performance.

...But Since 1974, Capital Productivity In Steel Runs Behind Other Manufacturing Industries...

Following the 1973 energy crisis, average annual capital productivity growth turned negative, declining at an average rate of 2.1 percent between the 1974 and 1979 output peaks. This was considerably worse than the -1.0 percent capital productivity growth in overall manufacturing.

FIGURE 65

Comparison Of Capital Productivity Growth Over
Comparable Peak-To-Peak Intervals
(Average Annual Percent Changes)



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

B.5 Labor Productivity, Labor Prices, And Unit Labor Costs

Unit Labor Costs Stable Between 1958-66, But Then Advance Rapidly...

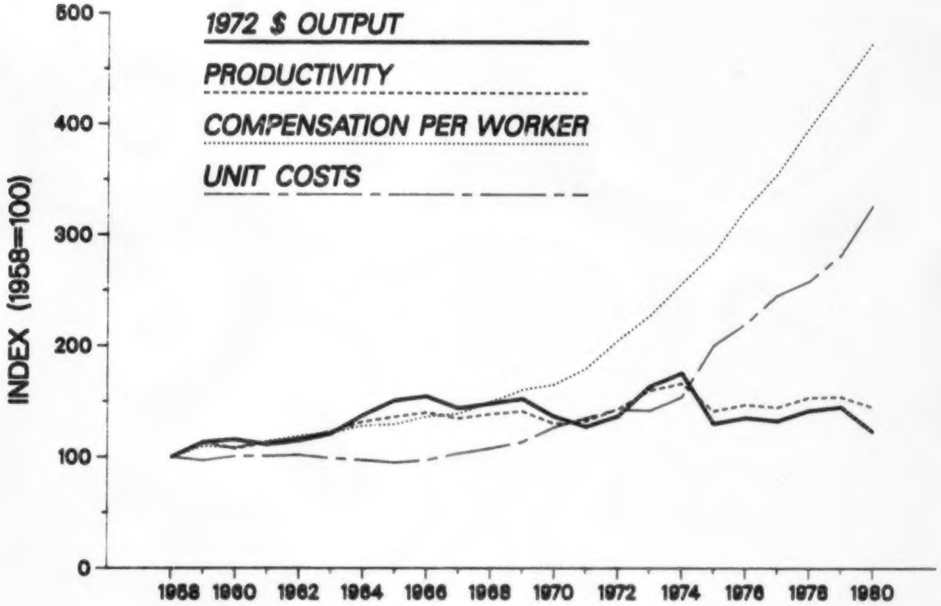
Figure 66 demonstrates the very close relationship that exists between the growth paths of labor productivity and real output. It also clearly demonstrates that unit labor costs escalated rapidly after 1966 and it tells us why -- labor productivity growth trends down while labor price growth trends up. Real output per employee in 1974 was 67 percent above the level in 1958, but only about 16 percent above the 1966 level. Significantly, the 1979 labor productivity level was almost identical to its 1966 level and 7.5 percent below its 1974 level; but the 1979 level of annual compensation per employee was more than 83 percent above its level in 1974 and almost 190 percent above its 1966 level. By 1980 compensation per employee was double its 1974 level.

...As The Post-1966 Growth Trends In Labor Compensation And Labor Productivity Move In Opposite Directions...

Figure 66 also shows that unit labor costs remained virtually unchanged between 1959 and 1966 -- the 1966 level was just 0.3 percent below its 1958 level. However, unit labor costs have increased substantially since 1966 -- with double-digit increase of 11.2, 26.2, 11.0, and 14.6 percent occurring in 1970, 1975, 1977, and 1980 respectively. The 1966-74 average rate of increase was 5.7 percent, but the 1974-79 average was 12.0 percent. As a result, by 1980, unit labor costs were 3.3 times their 1958 level and 2.1 times their 1974 level.

FIGURE 66

Output, Labor Productivity, Labor Prices, And Unit Labor Costs, 1958-80



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

...Labor Productivity Growth Matches Growth In Labor Prices Through 1966, In Line With Other Manufacturing Industries...

Figure 67 shows that unit labor costs in steel grew at an average annual rate of just 0.1 percent between the peak years of 1959 and 1966. During this time, 3.1 percent labor productivity growth matched the 3.1 percent labor price growth.

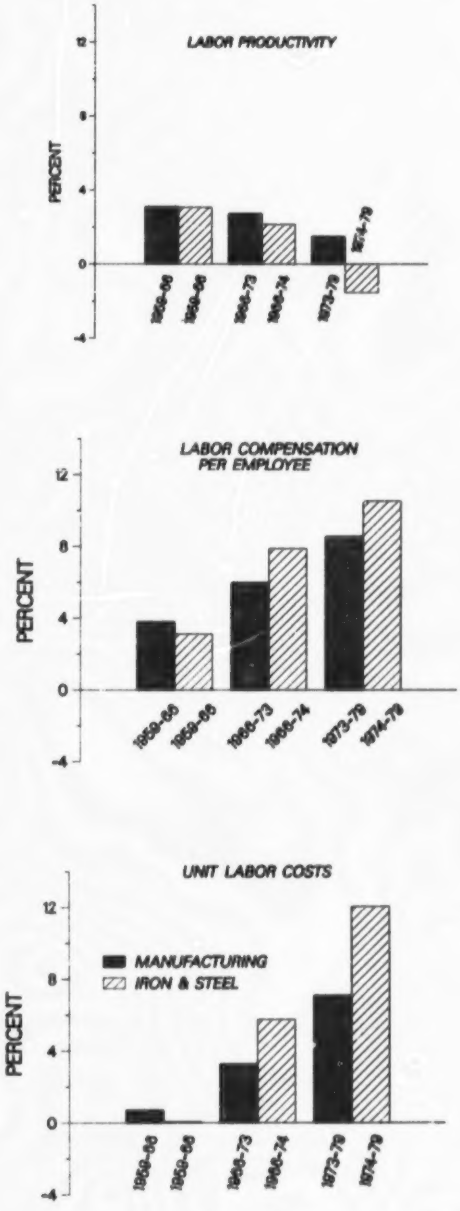
...But Labor Prices Grew Faster Than Labor Productivity And Faster Than Prices In Other Manufacturing Industries Since 1966.

Over the next peak-to-peak interval, 1966-74, unit labor cost growth accelerated to an average annual rate of 5.7 percent; as labor prices grew at a 7.9 percent average rate, while labor productivity improvement slowed to 2.1 percent. This imbalance worsened by a factor of two during the 1974-79 interval. Unit labor costs advanced at an average annual rate of 12.0 percent; as labor prices grew at a 10.5 percent rate, while labor productivity growth declined at a 1.5 percent rate.

Figure 67 shows that the steel industry's unit labor costs grew much more rapidly in the 1966-74 and 1974-79 periods than those costs in manufacturing because of steel's above-average growth in labor compensation and its below-average growth in labor productivity.

FIGURE 67

Labor Input Comparison Over Comparable Peak-To-Peak Intervals (Average Annual Percent Changes)



SOURCE: Office of Business Analysis, U.S. Department of Commerce

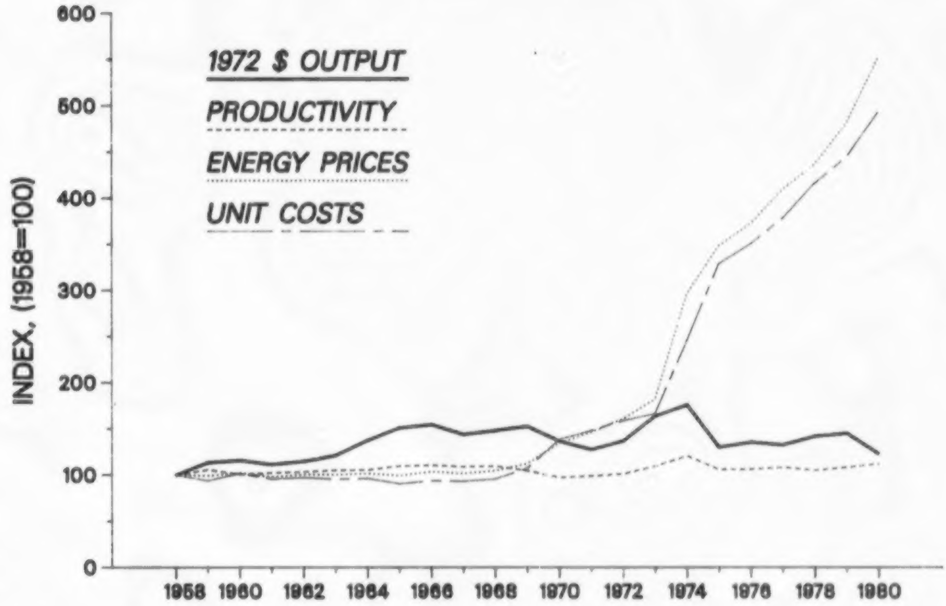
B.6 Energy Productivity, Energy Prices, and Unit Energy Costs

Unit Energy Costs Declined Slightly Through 1968, But Then Advanced, With Big Jumps in 1969-70, 1974-75 And 1979-80...

Figure 68 shows the growth paths of energy productivity, unit energy costs, and unit energy prices relative to the growth path of real output. Over the entire 1958-80 interval, energy productivity was virtually flat. The 1966 index of energy productivity was 110.6 (1958=100), while the 1974 and 1979 indexes were 120.6 and 108.2, respectively. Unit energy costs were also relatively stable through 1968, with costs in the latter year 4.4 percent lower than the 1958 level. Thereafter, unit energy costs rose persistently and rapidly, with double-digit jumps occurring in 1969, 1970, 1974, 1975, and 1980. The 1974 unit cost index stood 145.3 percent above the 1958 value, and the 1980 index was almost 400 percent higher.

FIGURE 68

Output, Energy Productivity, Energy Prices, And Unit Energy Cost, 1958-80



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

...As Energy Prices And Productivity Both Showed Modest But Offsetting Increases 1958-66...

Figure 69 shows that no growth in unit energy costs occurred between the 1959 and 1966 output peaks -- the result of a 0.6 percent average rate of increase in energy prices and by an 0.7 percent average growth in energy productivity.

...But Very Slow Energy Productivity Improvements Were No Match For Huge Energy Price Increases In 1966-74...

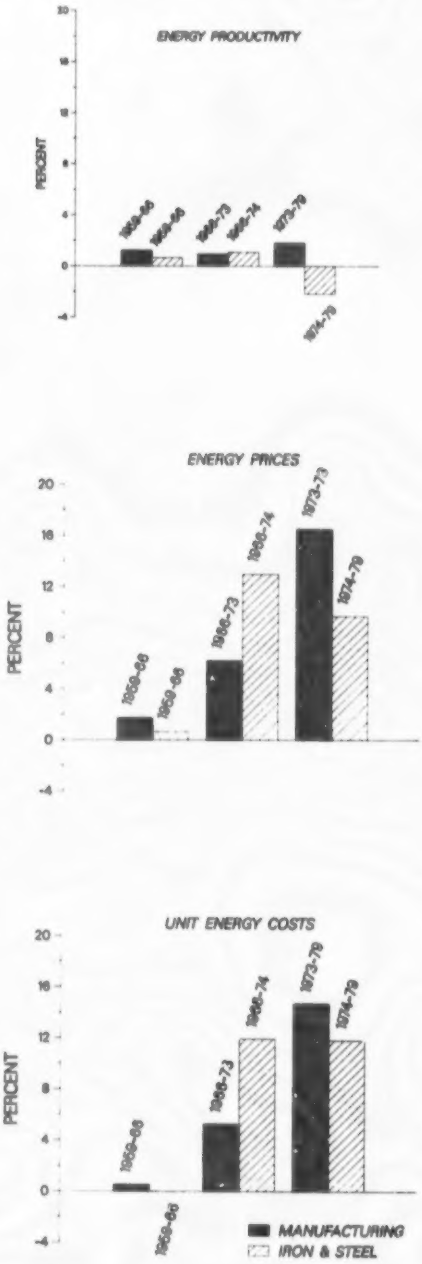
The stability in unit energy costs came to an abrupt halt in 1969, and unit energy price stability came to an equally abrupt stop in 1970, when prices jumped 18.3 percent. Moreover, unit energy prices escalated 46.67 percent in 1974, while unit energy costs rose at 38.3 percent. During the 1966-74 peak-to-peak interval, unit energy costs grew at an average rate of 11.9 percent, as average energy productivity growth of 1.1 percent was overwhelmed by a 13.0 percent average annual growth in the unit price of energy inputs.

...And Again In 1974-79, As Large Negative Growth In Energy Productivity Reinforced Near Double-Digit Energy Price Increases...

Unit energy prices took another large (17.6 percent) jump in 1975, but unit energy costs advanced almost twice as fast (29.1 percent). Between the 1974 and 1979 output peaks, unit energy costs grew at an 11.8 average annual rate -- virtually identical to the 1966-74 rate. The reason: energy prices grew at a 9.7 percent average annual rate while energy productivity declined at an average rate of 2.2 percent, compared with positive energy productivity growth of 1.8 percent recorded by manufacturing industries overall.

FIGURE 69

Energy Input Comparison Over Comparable Peak-To-Peak Intervals (Average Annual Percent Changes)



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

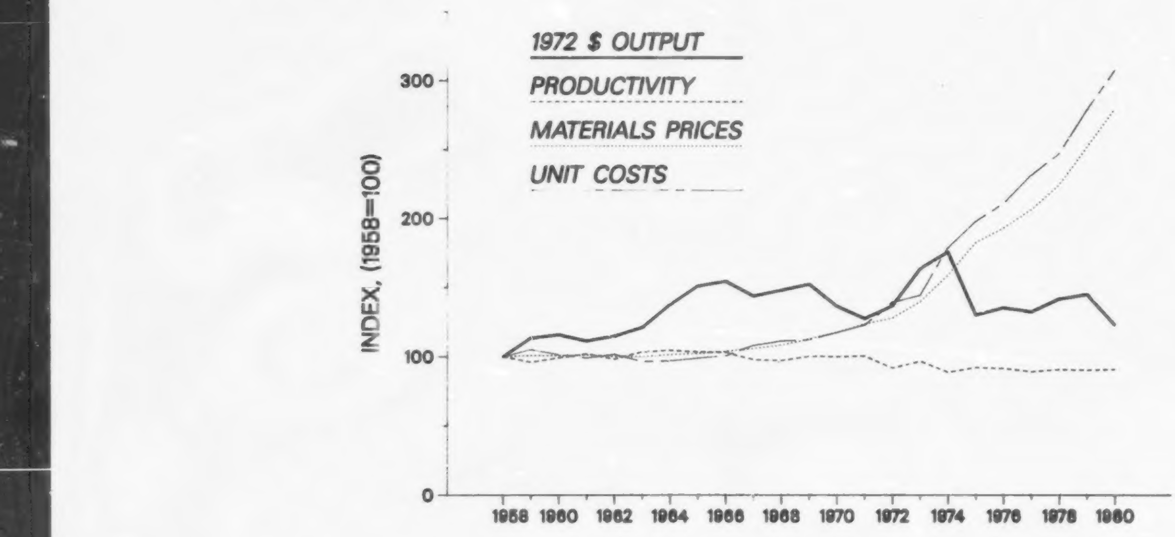
...But Captive Coal Supplies Protected The Industry From Much Of The Post-1973 Energy Price Inflation.

Despite this, Figure 69 demonstrates that the Post-1973 peak-to-peak growth in unit energy costs was very much in line with that found in other manufacturing industries, but only because its unit energy prices advanced at a much slower rate. In fact, its 1974-79 peak-to-peak average rate of price growth was only about half the post-1973 peak-to-peak rates recorded for all-manufacturing. The reason is that the industry owns much of its major energy sources. Coal converted into coke and breeze is the major energy input. In 1958 coke and breeze accounted for more than 61 percent of direct energy inputs, but this share fell to 44.2 percent by 1980. Between 1973 and 1980, steel's unit coal prices advanced only 155 percent, compared with 219 percent and 335 percent for its oil and natural gas prices.

B.7 Materials Productivity, Materials Prices, and Unit Materials Costs

FIGURE 70

Output, Materials Productivity, Materials Prices, And Unit Materials Cost, 1958-80



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

Unit Materials Costs Stable Through 1966 But Inflated Sharply Thereafter...

Figure 70 shows that efficiency in the use of material inputs by the steel industry has actually declined. Virtually no change in the ratio of real materials to real output occurred between 1958 and 1966 -- the 1966 index of materials productivity was only 3.2 percent higher than its 1958 value. Thereafter, the level of productivity declined so that the 1974 productivity index was 10.0 percent below its 1958 level. Again, virtually no change took place between the 1974 and 1979 output peaks; the 1979 materials productivity index was just 9.7 percent below the 1958 value. Increasing use of inferior iron ore (called taconite ore) between 1966 and 1974 likely accounts for much of the materials productivity decline during this period. Taconite ores typically contain about 30 percent iron, requiring it to be further refined, through a process called beneficiation and pellitization, into pellets containing 65 to 72 percent iron.

Figure 71 shows that steel's materials productivity growth profile is not unique. The production processes of most manufacturing industries appear to convert materials inputs into output according to a fixed-proportions technology, with improvements in the respective industry proportions occurring only very slowly over time.

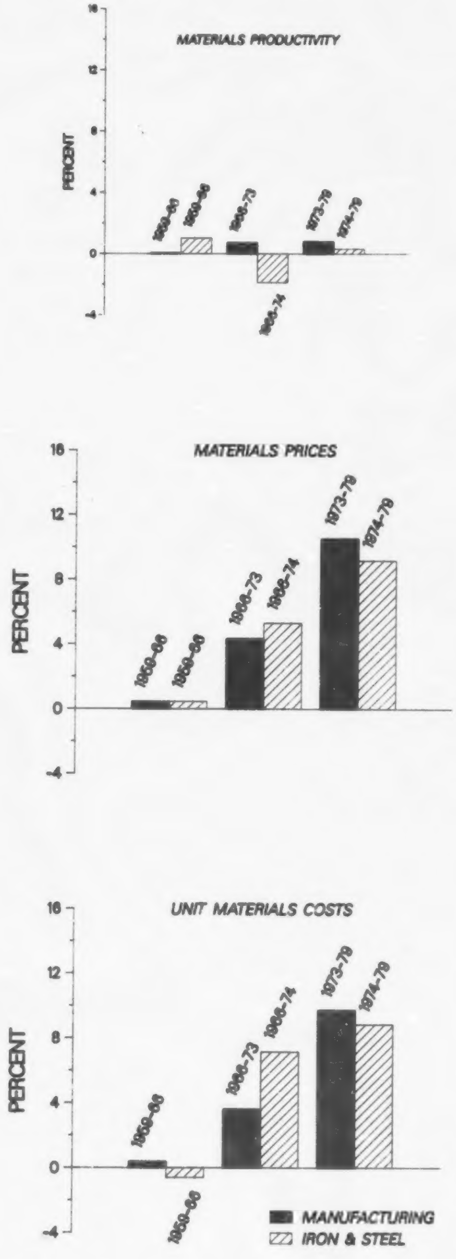
Similarly, the level of unit materials cost was virtually static between 1958 and 1966, with the 1966 index almost identical to its 1958 value. After 1967, however, the unit materials costs began a steep and uninterrupted upward spiral; punctuated by double-digit growth in 1972, 1974, 1975, and 1979. The 1974 unit cost index stood almost 80 percent above its 1958 and 1966 levels,while the 1980 index stood 208 percent above it. The growth in iron ore prices accounted for a major portion of the materials cost inflation. Between 1973 and 1980 the price of iron ore increased more than 250.0 percent.

...As Modest Productivity Growth Completely Offset Moderate Price Growth During 1959-66...

Figure 71 shows that, during the 1959-66 peak-to-peak interval, unit materials costs actually had a negative average rate of growth (-0.6 percent); because productivity in the use of materials grew at an average rate of 1.0 percent while the unit price of materials inputs grew at only a 0.4 percent average rate. Similar results occurred in total manufacturing.

FIGURE 71

Materials Input Comparison Over Comparable Peak-To-Peak Intervals (Average Annual Percent Changes)



SOURCE: Office of Business Analysis, U.S. Department of Commerce.

...But, Negative To Flat Materials Productivity Growth Reinforced Inflation In Unit Materials Prices 1966-79.

During the 1966-74 interval, unit materials cost increased at an average rate of 7.2 percent, because materials productivity growth declined at 1.9 average annual rate while unit materials prices rose at an average rate of 5.3 percent.

Unit materials costs continued to escalate in the 1974-79 interval. The 8.9 percent average rate of increase was the result of an 9.2 percent average rate of price increase and an anemic 0.3 percent average rate of materials productivity growth. Similar changes in materials prices and productivity growth also occurred in total manufacturing during that time interval.

Closings Of Obsolete Plants And Increased Investment In Technically Advanced Capital Since 1979 Should Greatly Improve Energy And Materials Efficiency.

In the aftermath of the protracted recession and very weak recovery that has gripped the U.S. iron and steel industry from 1980 through the first half of 1985, the industry has undertaken several cost-cutting initiatives which should yield major improvements in the yield of real output received per unit of aggregate real energy and materials inputs consumed. These initiatives include the large scale closing of many inefficient plants and facilities and the rapid growth in the proportion of total steel production coming from energy and materials-efficient technologies -- electric arc furnaces and continuous casting in particular. The former requires much less materials input and one-third the energy consumed by the conventional blast furnace/basic oxygen furnace method of making raw steel, and the latter uses 15 to 20 percent less raw steel and 40 to 50 percent less energy than the traditional ingot method/reheating furnace method for the same amount of finished steel product. In 1981, 28 percent of the raw steel produced by the industry came from the electric arc furnace and only 29 percent was conticast. By the end of 1985, however, these percentages are expected to rise to 32 and 40 percent, respectively.

Summary

THE STEEL INDUSTRY IN PERSPECTIVE

Between 1958 and 1966, the growth of productive efficiency in the U.S. steel industry compared favorably with other U.S. manufacturing industries. Its unit cost of production declined at an average annual rate of 0.4 percent between its 1959 and 1966 output peaks. This compares with growth rates during comparable peak-to-peak periods of 0.5 percent for total manufacturing, -0.8 percent for plastics and synthetic materials, and -0.1 percent for autos.

The total-input productivity growth derived from its four input categories -- capital, labor, energy, and materials -- also compared favorably to the growth found in total manufacturing and in the two selected industries through 1966. Total-input productivity grew at an average annual rate of 1.8 percent between the output peaks of 1959 and 1966, compared with average annual peak-to-peak growth rates of 1.2, 1.7, and 2.1 percent in all-manufacturing, plastics, and autos, respectively. More importantly, there was a balance between the growth in productivity derived from its two most important input categories -- labor and nonenergy materials -- and the growth in the prices paid for these two input categories.

After 1966, however, the growth in steel's economic efficiency was adversely affected by a combination of repeated business recession shocks -- in 1967, 1969-71, 1975-77, 1980-83; by energy and/or materials price shocks in 1970, 1973-1974, and 1979-1980; -- and by general inflation since 1966. Although these post-1966 shocks were a common experience of most U.S. manufacturing industries, their effect on the steel industry appears to have been more intense and long lasting. In fact, it is fair to characterize the U.S. steel industry as having been in a state of quasi-permanent recession since 1966; with the 1979 peak output level well below that of the 1974 peak and even below that of the 1966 peak. In fact, if 1974 is excluded, the output growth trend of the industry has been systematically downward since 1966.

In general, the four-input efficiency performance of the U.S. steel industry, like its output growth performance, has lagged behind that of other U.S. industries since 1966; and especially so since 1974. Peak-to-peak total-input productivity growth in steel declined from a 1.7 percent average annual rate during 1959-66, to 0.1 percent during 1966-74, and to -0.8 percent during 1974-79. In comparison the comparable peak-to-peak growth rates in all-manufacturing were 1.2, 1.0, and 0.6 percent; in plastics they were 1.7, 2.7, and 1.3 percent, and in autos they were 2.1, 1.7, and 0.2 percent.

But, it has been particularly out of line with respect to labor. The 12.0 percent average annual growth in steel's unit labor costs since 1974 has outpaced that of total manufacturing by 4.9 percentage points. Simply put, the problem is that, since 1966, labor price growth has lost its historic relationship to the growth in labor productivity. In fact, since 1974 they have been moving in opposite directions -- with labor compensation per employee advancing at the average annual rate of 10.5 percent and labor productivity declining at a 1.5 percent rate.

Overall labor compensation grew at an average annual rate of 10.8 percent from 1973 to 1980, compared with 8.6 percent for all manufacturing. It was also 0.7 and 1.3 percentage points higher, respectively than the growth rates found in plastics and autos. The most outstanding contrast, however, is found in steel's labor productivity growth since 1973. On a peak-to-peak basis, labor's negative 1.5 percent growth during the 1974-79 interval compares with positive productivity growth of 5.8 percent in plastics (1974-79), of 2.3 percent in autos (1973-78), and of 1.5 percent in overall manufacturing

(1973-79). In addition to poor labor productivity growth, the industry's deteriorating unit total-input cost growth performance since 1974 was reinforced by its well below average peak-to-peak productivity growth in capital, energy, and materials as well.

However, this portrait of industrial deterioration does not apply to the mini-mill segment of the industry. The decline of the U.S. steel industry has been the decline of its integrated segment; indeed, the mini-mill segment has experienced strong profits and continued growth, capturing markets from both the domestic-integrated segment and foreign steel producers. The difference between the two sectors of the industry can be largely attributed to mini-mills use of more efficient and cheaper steelmaking technologies (electric arc furnace and continuous casting); to the employment of a flexible, nonunion workforce; to a more harmonious labor-management relationship, based on the widespread use of employee productivity incentives -- employee involvement, training, and profit-sharing programs; and to the urban location of plants, close to both their major raw material (scrap) and their customers.

The Decline Of Integrated Steel: Why Did It Happen?

Why did the integrated segment of the U.S. steel industry experience such a profound loss in production efficiency? This report delineated several contributing factors. It is important to note, however, that, with few exceptions, each of them is closely interrelated with every other factor. The schematic shown in Figure 72 (Panels A and B) illustrates this fact and summarizes the important findings of this report with reference to the dynamics of how the steel industry arrived at its present state.

Panel A shows that the dominant characteristic of the overall U.S. steel industry since the mid-sixties has been one of declining production and sales. It also delineates the four factors which directly caused this phenomenon:

1. Changing composition of the U.S. economy -- away from goods-producing and steel intensive industries toward service-producing industries;

2. Intensified business cycle activity and rapid inflation since the mid-sixties;

3. Loss of steel markets to substitutes for steel, e.g., plastics and aluminum;

4. Loss of domestic steel markets to foreign steel producers.

Of these four factors, only are the first two are arguably the results of events largely exogenous to the steel industry. In contrast, the third and fourth factors are largely the result of cause and effect relationships over which the integrated segment of the industry had much direct control. That is, they were the result of a decline in the competitive posture of the integrated mills, which in turn was the direct result of their declining production efficiency -- high and rising input price growth and low and declining input productivity.

Panel B summarizes the important causes and interactions underlying the increasingly noncompetitive production costs of the integrated mills; it also illustrates a central finding of this report: the important role of labor-related factors in the competitive decline of the domestic, integrated steel industry and the mechanisms through which these factors worked.

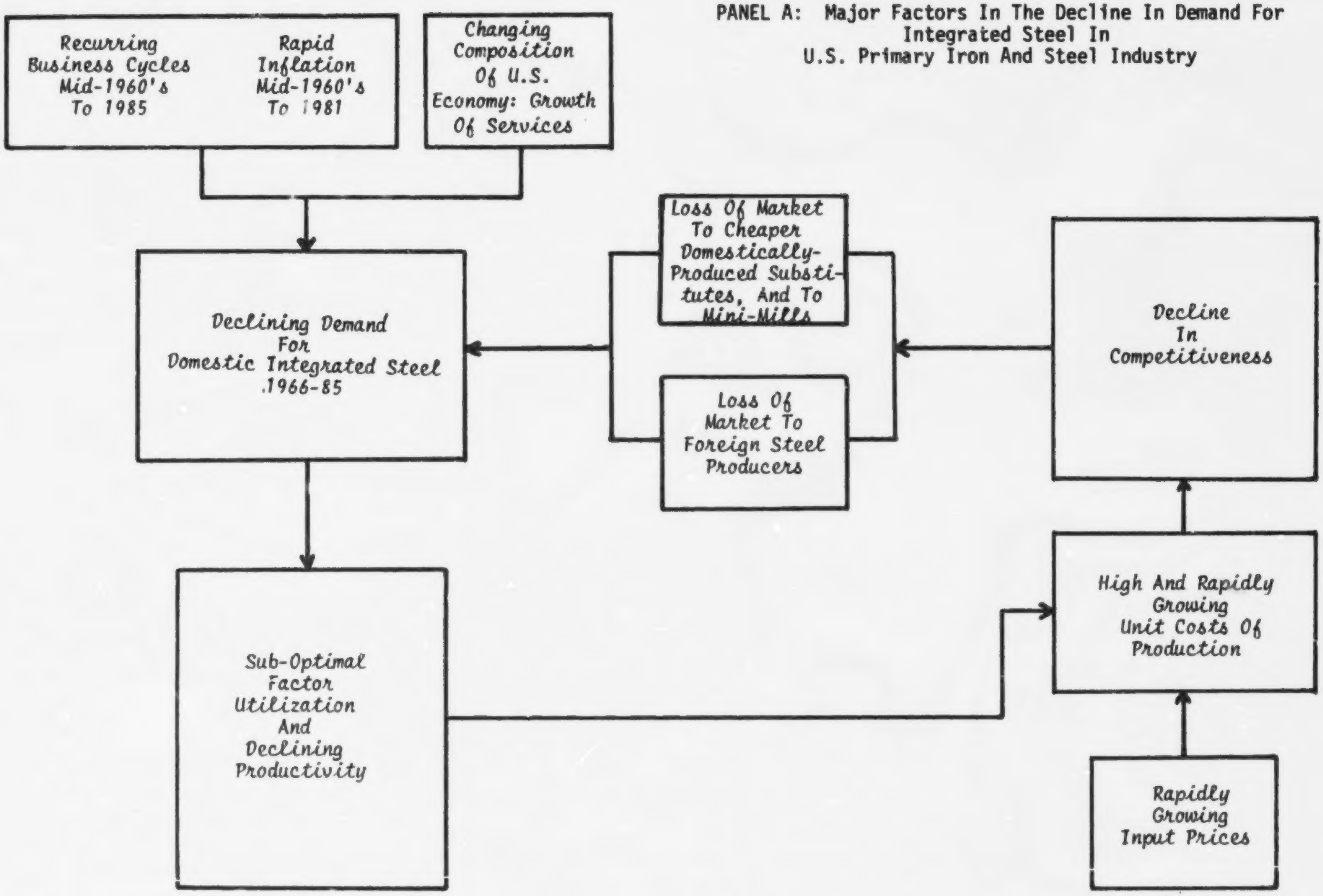
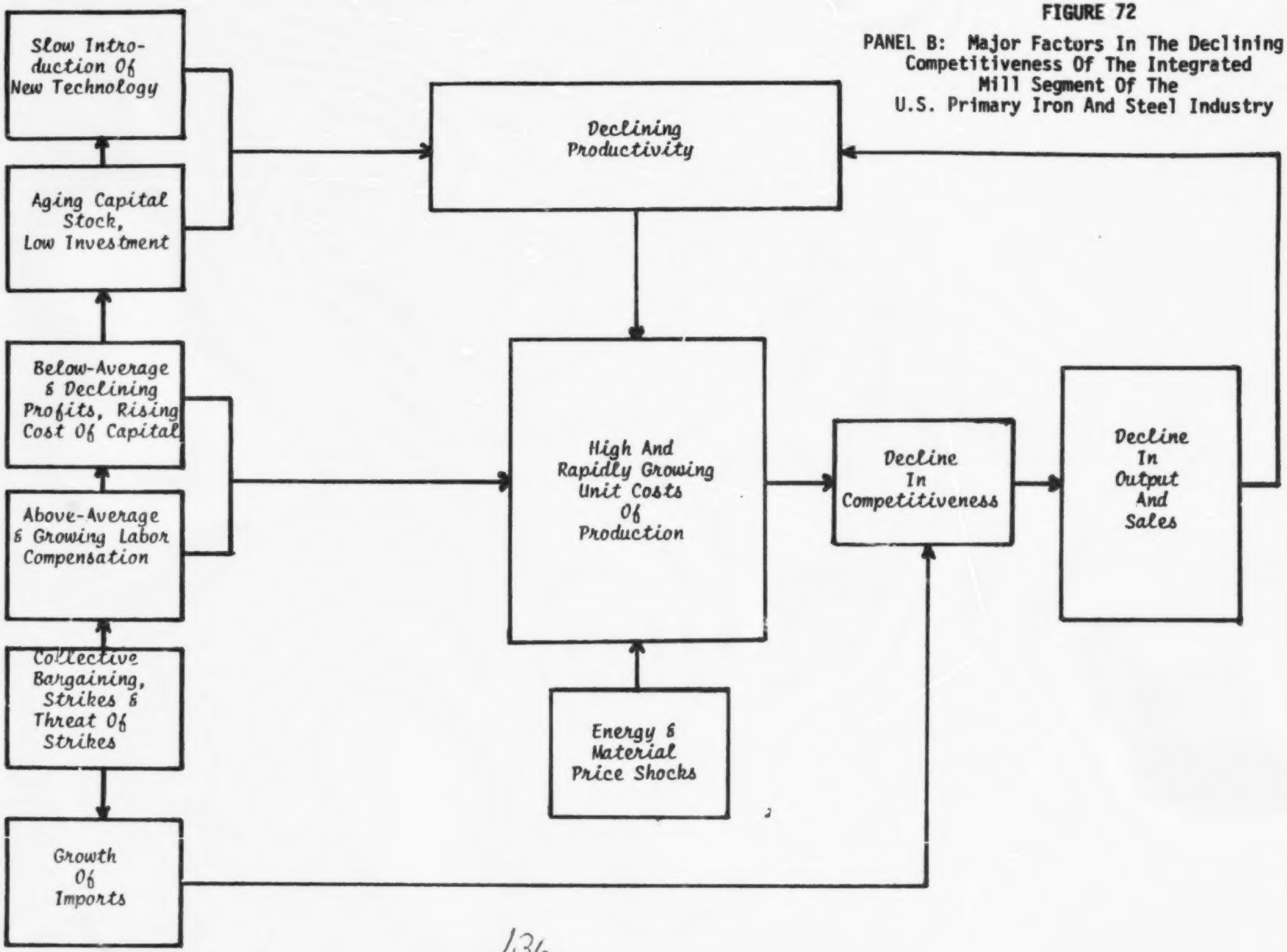

Recurring Business Cycles Mid-1960's To 1985
Rapid Inflation Mid-1960's To 1981
Changing Composition Of U.S. Economy: Growth Of Services
Declining Demand For Domestic Integrated Steel 1966-85
Loss Of Market To Cheaper Domestically-Produced Substitutes, And To Mini-Mills
Loss Of Market To Foreign Steel Producers
Decline In Competitiveness
Sub-Optimal Factor Utilization And Declining Productivity
High And Rapidly Growing Unit Costs Of Production
Rapidly Growing Input Prices

FIGURE 72

PANEL A: Major Factors In The Decline In Demand For Integrated Steel In U.S. Primary Iron And Steel Industry

FIGURE 72

PANEL B: Major Factors In The Declining Competitiveness Of The Integrated Mill Segment Of The U.S. Primary Iron And Steel Industry


Slow Introduction Of New Technology
Aging Capital Stock, Low Investment
Below-Average & Declining Profits, Rising Cost Of Capital
Above-Average & Growing Labor Compensation
Collective Bargaining, Strikes & Threat Of Strikes
Growth Of Imports
Declining Productivity
High And Rapidly Growing Unit Costs Of Production
Energy & Material Price Shocks
Decline In Competitiveness
Decline In Output And Sales

Although the industry enjoyed sufficient market power to set prices and to earn above-average markups over normalized costs, 1/ a large and increasing portion of the markup was used to maintain the large compensation premium paid to steelworkers and to support its growth. For example, during its 1959-66, 1966-74, and 1974-79 peak-to-peak intervals, the U.S. primary iron and steel industry earned markups that exceed those of the U.S. manufacturing sector overall (during comparable peak-to-peak intervals) by 31, 19, and 28 percent, respectively; and exceeded those earned by the U.S. motor vehicles and parts industry (during comparable peak-to-peak intervals) by 29, 3, and 10 percent, respectively. More importantly, however, the steel industry consumed 25, 25, and 35 percent, respectively, of the markup that it earned over nomalized costs during these three intervals to maintain the compensation premium paid to steelworkers. In comparison, the motor vehicles industry consumed approximately only 12, 14, and 20 percent of its markup over normalized costs in this manner. This state of affairs earned production workers in steel a 40 percent pay premium over their all-manufacturing counterparts during the 1959-66 period, increasing to a nearly 80 percent differential by the 1979-80 period. And, nonproduction workers in steel earned a 24 percent compensation differential during 1959-66 but earned a 43 percent differential during 1979-80.

Reflecting the distribution of the markup, integrated mills earned below average profits since 1966 on production, and earned an after-tax rate of return on capital that has been below average since 1958 and that that has averaged less than one-half the all manufacturing rate since 1966. The rate of return declined from an average of 4.1 percent during the 1959-66 peak-to-peak interval, to 3.4 percent during the 1966-74 interval, and, excluding 1974, to 3.2 percent from 1974 to 1979. During the 1979-83 interval, integrated steel earned a negative 0.2 percent average annual rate of return. In comparison the corresponding rates of return earned by manufacturing industries overall were 7.7 percent (1959-66), 7.3 percent (1966-73), 8.8 percent (1973-79), and 8.4 percent (1979-83). As a consequence, integrated steel producers were forced to turn increasingly to debt financing, became increasing highly leveraged, and their composite cost of new capital grew rapidly in reflection of their increased riskiness to investors. During 1966-74, the cost of new capital averaged 1.0 percentage points more than the overall industry's rate of return, but the shortfall widened to an average of 3.2 percentage points during 1974-79.

Thus, Panel B shows that the industry's high and growing labor compensation burden also contributed to the decline of the integrated producers in two indirect ways: (1) by increasing the cost of capital to the industry, which led directly to further increases in its unit cost of production; and (2) by reducing the industry's ability either to maintain its existing stock of capital through replacement investment or to invest in new cost-saving technologies -- a vitally important factor in the industry's declining productivity growth, its rapidly rising unit production costs, and in its persistently deteriorating competitive position.

Finally, Panel B shows the direct linkage found by this report to exist between the industry's 3-year bargaining cycle (between integrated steel companies and the United Steelworkers Union) and the growth of imports. Not only did steel imports first become a significant factor in the U.S. as a result of the 119-day United Steel Workers strike of 1959, but also nearly 85 percent of the growth in imported steel between 1958 and 1980

1/ Normalized cost, as defined in PART III:Section B.1, excludes compensation paid to workers above the all-manufacturing rate, while the markup includes premium compensation payments to labor as well as capital income.

occured in the 3rd year of the bargaining cycle, as the industry's customers protected themselves against potential loss of supply from steel industry strikes. The Experimental Negotiating Agreement was instituted by the industry in 1973 to eliminate this phenomenon but it was ineffective and led to more than 11 percent per year growth in production worker compensation; thereby aggrevating further the direct and indirect labor compensation effects on the industry's unit production costs and competitiveness discussed above.

Outlook

Based on recent estimates from Iron Age and the OECD, 2/ estimated steel capacity in the free world (including newly industrialized countries) is expected to be between 575 and 610 million metric tons in 1990, compared with 595 million metric tons in 1980. However, it is estimated that free-world steel consumption will grow by only 20 million metric tons from its 1980 level of 463 million tons. Thus, world-wide excess capacity will still be in the 120 to 130 million range that existed in 1980 -- an amount equal to the entire 1985 capacity of the U.S. steel industry -- but well under the 200 ton excess that existed during heavily recession-affected 1983. This chronic excess capacity condition has led some industry observers to forecast that U.S. steel raw steel capacity will be reduced perhaps to 100 million tons by 1990, compared with its present 135 million tons.

All of this reduction in capacity will come from the integrated mill segment of the industry; indeed the mini-mill segment is expected to grow and to account for perhaps 40 percent of U.S. steel production sometime in the 1990's. However, the production efficiency and competitiveness of the surviving integrated steel producers will be well beyond what it was in either 1980 or in 1985. Indeed, with the efficiencies the companies are expected to achieve through restructuring, relocation, consolidation, labor givebacks, and large investments in cost-saving technologies, its output yield rate per unit of capital-labor-energy-and-materials inputs should approach that of both U.S. mini-mills and of foreign integrated steel producers. If so, the industry's long winter's night should finally end.

2/ **Iron Age,** December, 1983, p. MP-9; and "OECD Steel in 1981," Paris: OECD, 1983, p. 33.

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